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Chapter 1: General

1.1 Intention of the Manual: 25 Jan.2012

Efficiency and safety of operation at an airport can only be expected from facilities that are in good operational condition. Proper maintenance is the only key to keep the installations and facilities of an airport in good condition. Maintenance also 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.

1.1.1 The manual is intended to give guidance to aerodrome operators on planning and conducting maintenance work on the airport. The guidance has been developed on the basis of related ICAO Documents which, in turn, were 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 manual should be considered a specification. Maintenance work shall be planned on the basis of local needs, experience and recommendations of manufacturers of components and be carried out as per the approval of the appropriate authority.

1.2 Organization of the Manual: 25 Jan.2012

1.2.1 This manual 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 phases. In addition, some of the maintenance tasks supporting the airport efficiency have been included.

1.2.2 The requirements for safety reasons dominate the first part of the manual's contents, wherein the maintenance of visual aids, of electrical infrastructure, of pavements, of unpaved areas and of the drainage system is dealt with. Availability of suitable equipment is the tool for complying with the maintenance requirements of fixed facilities. Aircraft removal equipment represents a very special type of airport equipment. The material in this manual is complementary to the *Airport Services Manual,* Part *5,* which deals with removal procedures.

1.3 Organization of the Maintenance: 25 Jan.2012

1.3.1 Inspection is very vital part of maintenance. It 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.

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

1.3.3 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 programmes. The computer is less effective for maintenance control of buildings and pavements, where repair work upon notice will always prevail.

1.3.4 Management should check the work carried out against scheduled maintenance tasks and thereby achieve the full control of the progress of maintenance and budget. Compliance reports are the feedback and have to be recorded, as well as observations on any reported deficiencies.

1.3.5 Updated maintenance programmes will allow:

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

1.3.6 All maintenance programmes 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.

1.4 Requirement of workshops at the airport:

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 size of the workshop and types of equipments to be available will of course depend on

a. the volume of maintenance to be done at the airport;
b. the availability of skilled maintenance personnel; and
c. availability of close-to-airport workshops or craftsmen that may be used for maintenance work on contract basis;
d. compliance with airport emergency plan; and
e. economic aims.

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.

1.5 Categories of maintenance:

There are two categories of maintenance, namely-

a) Corrective / Regular Maintenance,
b) Preventive Maintenance.

1.5.1 Regular / Corrective maintenance:

Corrective maintenance can be defined as the maintenance which is required to bring an item back to working order when it has failed or worn out. Corrective maintenance shall be carried out on items where-

a) the consequences of failure or wearing out are not very significant, and
b) the cost of corrective maintenance is not greater than preventive maintenance.

Corrective Maintenance activity will consist of repair, restoration or replacement of equipment/ item. This activity will be the result of a regular inspection, which identifies the failure in time for corrective maintenance to be planned, scheduled and effected.

1.5.2 Preventive maintenance:

Preventative maintenance is the maintenance which is carried out to prevent an item failing or wearing out. Preventive maintenance shall be implemented by providing systematic inspection, detection and prevention of incipient failure. Preventive maintenance shall be carried out on items where-

a) the consequences of failure or wearing out are significant, and
b) the cost of corrective maintenance is greater than preventive maintenance.

The items falling under preventive maintenance would be e.g. lift, fire alarms, monitoring lamps for important equipment, electricity supply etc.

Chapter 2: Maintenance of Visual Aids

2.1 Introduction:

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 service-ability which in turn depends upon the effectiveness of the maintenance work carried out. Annex 14, Chapter 1 defines a light to have failed when its light output falls below 50 per cent of that specified for a new light. The loss of in light output can be due to the following two causes:-

a. Contaminants outside and inside the light unit, and
b. 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. Reference is made to Annex 14, Chapter 9.

2.2 Different types of Visual Aids:

Different types of visual aids used at airports are as follows:

a. Runway edge lights , center line lights, touch-down zone lights, threshold lights, stop bar lights, runway end lights etc.
b. Taxiway edge lights, center line lights, taxi stop bar lights etc.
c. High intensity approach lights, low intensity approach lights, strobe lights, VASI / PAPI etc.

d. Aerodrome beacon, wind direction indicators, obstruction lights etc.
e. Markings and signs etc.

2.3 Performance level objectives for Visual Aids:

The Performance level objectives for visual aids shall be as given below. This performance level shall be maintained through scheduled, unscheduled and preventive maintenance.

SN	Light category	Minimum acceptable light output (% of specified value)	Minimum acceptable % of serviceable light		Consecutive lights, more than numbers given below, shall not remain unserviceable
1	Rwy edge lights	50 %	a) For Cat-1 operation, at or above prescribed visibility	95 %	2
			b) When RVR is less than 550 M	95 %	
2	Rwy center line lights	50 %	a) For Cat-1 operation, at or above prescribed visibility	85 %	2
			b) When RVR is less than 550 M	95 %	
3	Rwy end lights	50 %	a) For Cat-1 operation, at or above prescribed visibility	85 %	2
			b) When RVR is less than 550 M	95 %	
4	Twy Stop-bar lights	50 %	Not more than 2 lights shall be U/S.		2
5	Rwy THR lights	50 %	85 %		-
6	TDZ lights	50 %	90 %		-
7	Approach lights	50 %	a) Beyond 450 M	85 %	-
			b) Within 450 M	75 %	

Note: With respect to barrettes, crossbars and runway edge lights, lights are considered to be adjacent if located consecutively and:

- ¾ laterally: in the same barrette or crossbar; or
- ¾ longitudinally: in the same row of edge lights or barrettes.

2.4 Personnel:

Electricians to be entrusted with the task of maintenance of lighting aids shall have the following qualifications / qualities:

a. Be experienced with high voltage series circuits and lighting;
b. Be fully acquainted with the work to be done;
c. Be present or available on call during the operating hours of the airport to correct any deficiencies that might develop;
d. Be provided with appropriate training to maintain their competence and to keep them abreast of new developments.

2.5 Spare parts:

An adequate stock of spare parts should be available. The required level of stock will depend on the following criteria:-

a. Rate of consumption of the items;
b. Time required to get the resupply of the items;
c. Shelf life of the items.

2.6 As-built drawing:

A set of as-built drawings shall be kept readily available in the Maintenance unit. The as-built drawings shall be kept in the following manner:-

a. Drawings shall be kept in the Maintenance unit and in the concerned Engineer's office;
b. Drawings must be kept up to date and any changes at site shall be reflected immediately on these drawings.
c. The completeness and the accuracy of all circuit diagrams, drawings and descriptions shall be checked at least annually.

2.7 Preventive maintenance of Visual aids:

A system of preventive maintenance of visual aids shall be employed to ensure lighting and marking system reliability. Procedures of preventive maintenance shall be as follows:-

a. Light bulbs shall be considered unserviceable and be replaced when their brightness falls below 50% of normal value.
b. The specifications from the Manufacturers regarding the normal life time of all the items of visual aids, shall be made available with the maintenance personnel, and light bulbs shall be replaced after 90% of the manufacturer's prescribed life time has elapsed.

c. In case when manufacturer's specification is not available, light bulbs shall be replaced after 90% of the average life time of the bulbs has elapsed.
d. Light fittings, fasteners and their supporting structures which may be damaged by rust shall be painted annually. Preferable period for such work shall be between January and April each year.
e. Cable lives of all concerned sections of visual aids shall be verified and cables shall be replaced whenever there is any threat to the system to be hampered for damage of cables due to aging.
f. Functions of all other items shall be closely monitored and shall be replaced whenever there is any threat to the system to be hampered due to aging of those items.

2.8 Basic components of maintenance:

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/ Monitoring;
   (The unserviceable lights can be identified more easily during night inspections, and of course, possible failures can be noticed by the operator at the Control desk if appropriate electric monitoring system is there.)
b. Servicing and overhaul; and
c. Repair.

2.8.1 Regular maintenance and Inspection:

Inspection is a vital part of maintenance. An inspection programme shall be prepared and be strictly followed. As the frequency of inspection will vary according to the hours of operation of the airport, inspection programme shall be prepared keeping pace with the hours of operation of the airport and flight schedule. Maintenance personnel of supervisor category shall regularly inspect the visual aids to assess the requirement of maintenance, and maintenance work shall be done immediately. For expediting the job, maintenance personnel shall be included in the inspection team to do the maintenance job instantaneously.

2.8.2 Recording of Inspection and Maintenance reports:

a. Daily report of the maintenance work done during the last 24 hours shall be raised by the maintenance personnel and shall be sent to the concerned Engineer's office. The Engineer shall verify the genuinity of the report and preserve in his office as record.
b. Copy of the report shall be sent by the Engineer to the Airport Manager (Attention: SATO). Airport Manager / SATO shall verify the maintenance report against the

Daily IOU report and take necessary action. Significant discrepancies shall be consulted with the concerned engineers. Reports shall be preserved as record.

2.8.3 Daily IOU Reports:

a. Daily report of the serviceability status (IOU report) shall be raised by the maintenance personnel and shall be sent to the concerned Engineer's office. The Engineer shall verify the report against the daily maintenance reports and preserve in his office as record.
b. Copy of the report shall be sent by the Engineer to the Airport Manager (Attention: SATO). Airport Manager / SATO shall verify the maintenance report against the Daily maintenance report and take necessary action. Significant discrepancies shall be consulted with the concerned engineers. Reports shall be preserved as record.
c. Airport Manager shall send the report to CAAB HQ [Attention: D (ATS & Aero, and D (FS&R)], through the best available means.

2.8.4 Inspection and Maintenance Team:

A team for the inspection and maintenance of visual aids shall be formed with at least three members out of the following five persons, where No. a, or No. b, and No. e, shall be included:

a. Assistant Engineer, E/M
b. Sub-assistant Engineer, E/M
c. E/M Foreman,
d. Electrician,
e. One Security personnel.

2.9 General procedures of Maintenance:

At the time of maintenance of the lights the following general procedures shall be followed:-

a. The instructions of the appropriate authority, based on the recommendations of the manufacturer shall be followed.
b. Maintenance schedule shall be prepared and records of maintenance of each piece of equipment shall be maintained.
c. This can be arranged in a dated reminder file to make sure that each equipment is serviced regularly.
d. This record should have space to enter observations, action taken and signature of the Technicians.
e. If situation demands, a change in the schedule may be effected with the approval of appropriate authority and in consultation with the equipment manufacturer, if applicable.

2.10 Frequency of checks:

a. Frequency of inspection and servicing will vary according to the type of equipment, its location and usage.
b. A maintenance programme shall be prepared for each airport based on its past experience and with the objective of achieving required service standard.
c. The following schedules are presented as guidance material in establishing a preventive maintenance programme.
d. More frequent checks may required for higher categories of lights.
e. Each check shall be followed by appropriate corrective action.

2.10.1 Daily Checks:

(1) Runway, Taxiway, Approach, Threshold, PAPI and other Lights:

a. Burnt-out lamps shall be replaced.
b. Glass of each light to be cleaned and shall be replaced, as required.
c. Loose fasteners of light units shall be tightened.
d. Rusted and corroded light parts and reflectors shall be painted and replaced, if required.
e. Horizontal alignment of the light units shall be adjusted, as applicable.

(2) Inset lights:

a. Lenses o f inset lights shall be cleaned.
b. Light output of runway center line lights shall be measured and recorded; lenses shall be cleaned and replaced, if required.
c. Top parts of runway center line lights shall be checked and unserviceable parts shall be replaced, as required.

(3) Other Airport lights: Airport beacon, obstacle lights, signs markers etc:

a. Burnt-out lamps shall be replaced.
b. Control equipment shall be corrected or repaired, as required for proper operation.
c. Fabric of wind cone shall be replaced, as required.
d. Inscriptions legibility shall be ensured by repairing the signs and removing the obstructions, as required.

2.10.2 Monthly checks:

(1) Runway, Taxiway, Approach, Threshold, PAPI and other Lights:

a. Spreader glasses, filters and lamps shall be cleaned.
b. Light output of all lights within the system shall be measured and results shall be recorded; lenses shall be cleaned.
c. Elevation setting of the light units shall be adjusted, as required.

d. Control equipment shall be checked for proper operation at each brightness step; malfunctions shall be corrected and repaired, as required.

2.10.3 Half-yearly / Yearly Checks:

(1) Runway, Taxiway, Approach, Threshold, PAPI and other Lights:

a. Lamps of the whole system shall be checked; unserviceable lamps or, if required, lamps of the entire system shall be replaced.
b. Rusted and corroded light parts and reflectors shall be painted and replaced, if required.
c. Reflector of each light unit (if applicable), shall be cleaned, and replaced, if required.
d. Loose fasteners of light units shall be tightened.
e. Plug connections shall be checked and faultless connection shall be ensured by cleaning the dirty parts; if required, faulty plugs shall be replaced.
f. Elevation setting of the light units shall be checked and elevation shall be adjusted, as applicable.
g. Horizontal alignment of the light units shall be checked and alignment shall be adjusted, as applicable.
h. Supporting structure and the foundation of the units shall be repaired and painted, as required.

(2) Inset lights:

a. Lenses of inset lights shall be cleaned.
b. Lights shall be dried for moisture, if required.
c. Electrical connections of the lights shall be tightened and sprayed with contact agents for proper contact.
d. Alignment of the lights shall be adjusted, as required.
e. Prisms and filters of lights shall be cleaned or replaced, if required.
f. Sealing compound shall be changed shall be resealed.

(3) Other Airport lights: Airport beacon, obstacle lights, signs markers etc:

a. Power supply brushes and slip-rings of aerodrome beacon shall be cleaned; or replaced, if required.
b. Electrical connections of the lights shall be tightened.
c. Rotating parts shall be fastened.
d. Optical system of the beacon shall be checked and required remedial action shall be taken.
e. Glasses and gaskets of obstacle lights shall be cleaned; or replaced, if required.
f. Function of the Flashing lights and twilight switches shall be cleaned, repaired or replaced, if required.
g. Power supply and lighting of the wind direction indicator shall be repaired or replaced, if required.
h. Fastener of the wind direction indicator shall be tightened and structure shall be repaired, if required.

i. Supporting structure and the foundation of different units shall be repaired, as required.
j. Loose fasteners of obstruction lights shall be tightened.
k. Easy access to locations of obstruction lights, for maintenance, shall be arranged; if required and possible, location shall be changed.
l. Structure and mounting of both signs and their lighting shall be cleaned, repaired and replaced, as required; shall be repainted wherever applicable.
m. All markings on paved areas shall be inspected at least semi-annually; markings which are faded or discolored by soil shall be repainted.

(4) Docking guidance system:

a. Alignment of the system shall be adjusted.
b. Electric connections shall be checked for wear and tear; connections shall be cleaned, tightened and replaced, as required.
c. Control relays shall be cleaned and replaced, as required.
d. Structure of the system and function of all mechanical parts, shall be repaired and restored, as required
e. Total system shall be cleaned and dried, as required for proper functioning.

2.10.4 Non-schedule checks:

In addition to carrying out all the above mentioned scheduled maintenances, situations like some natural calamity, accidents, sabotage etc. may give rise to such situation when some out-of-schedule maintenance work will become essential.

2.11 Light Maintenance Procedures:

2.11.1 General hints for Maintenance of lights

Maintenance work can be done in two ways-

a. Indoor, and
b. Outdoor.

As far as practicable, maintenance work shall be carried out indoor. Outdoor maintenance has the following inconveniences:-

a. Heat, cold, precipitation etc.
b. Aircraft noise.
c. Traffic restrictions, interruptions etc.

2.11.2 Steps of Maintenance procedures

There are two steps in the commonly used maintenance procedure-

a. Removal of defective lights and replacement by new or repaired once;

b. Servicing and overhauling of deficiencies in the workshop where required tools and equipment are available.

The prerequisites to run the above system of maintenance are as follows:-

a. Provision of sufficient number of spares;
b. Requirements of spare parts will be determined by the past experience of rate of damage / consumption of the individual items;
c. Lights which are easy to install and repair should be used;

2.12 Cleaning procedures of lights

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 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 deposits 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.

2.12.1 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.

2.12.2 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.

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

2.13 Water inside lamps

Inset lights may sometime collect water. Water inside the lights causes the following problems:-

a. Increase corrosion;
b. Damage to electrical parts;
c. Deposits on lenses and lamps;
d. Reduces the life of the lamp.

2.13.1 Remedial actions against water inside the lamps:

Preventive and remedial actions against water inside lamp shall be as follows:

a. Before inserting a light into the pavement, good drainage of the opening must be ensured.
b. Regular inspection shall be made to check lights for presence of water, penetration of moisture and accumulation of water can not be prevented completely.

Lights found to be wet inside should be removed and replaced, if such a procedure is possible with the type of light. Other wise, drying must be carried out on the spot.

a. After drying, the sealings should be checked carefully and replaced when required.
b. 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.

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

2.14 Lamp Replacement

The life span of lamps varies from 100 to some 1 000 hours of operation. The life time depends on the percentage of operation at high brightness levels and on the number of switchings, dynamic stresses imposed by aircraft wheel loads (inset lights) and temperature-induced stresses inside the casing affect the lamp life. Lamps which have failed shall be replaced as soon as possible so that the lighting system of the airport meets the required maintenance level objectives stated in para 4.15 of this Manual. (Ref: Annex 14, Chapter 9).

2.14.1 Lamp replacement Procedures:

The following procedures shall be followed to replace the unserviceable lamps:

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.
c. The intervals between replacements have to be derived from local experience with the average life of lamps in use.
d. Lamps should be changed when they have been operated for 80 per cent of their average life.
e. For this maintenance method a reliable record of operating hours for the individual sections of the airport's lighting system is a required.
f. This method requires less frequent checks.

Lamp replacement in the workshop is preferable, particularly with inset lights. The unserviceable light shall 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,

2.15 Light Measurements and Output Standards:

2.15.1 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. **A light shall be considered to have failed when its output is less than 50% of the required intensity.** For practical reasons a light will be replaced when its output falls below 70 per cent of that specified for a new light. [Ref: ANO (AD) A-1, Para 10.4.1].

2.15.2 Light measurements shall be carried out regularly to detect early light output reduction. Appropriate equipment for both field and bench measurement of light output will be made 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.

2.15.3 Field measurements are particularly necessary for inset lights. Wheel loads on inset lights may frequently cause damage. Before measuring, the lights shall be cleaned and switched to the highest available intensity setting.

2.15.4 Light measurements shall be made by using the measuring equipment supplied by the light manufacturers or procured time to time, as required. The intensity is checked by comparison with the results of a calibration test with a new light.

2.15.5 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 per cent of maximum).

2.15.6 For adjustment of the correct angle of the beam, lights are normally furnished with alignment markings. Beam misalignment caused by displacement of the optical system inside, which cannot be corrected by adjusting the casing, shall be adjusted in the workshop.

2.15.7 For measuring light output in the workshop microammeter readings shall be compared with the calibration value. Directional adjustments shall be made using the alignment screws.

2.16 Maintenance of Signs and Markings:

Signs and Markings give pilots directional information for taxiing and holding. Maintenance should ensure integrity and perfect legibility of the information provided by them. The design and construction of signs varies considerably and maintenance system may also vary; but the general checks and maintenance, as given in articles 4.10 shall be followed and, if required, additional system may be adopted with the approval of appropriate authority.

Chapter 3: Maintenance of Airport Electrical System

3.1 Introduction:

The serviceability and reliability of air navigation equipment and installations are requirements for safe operation of aircraft in airport area. Apart from visual aids, the air navigation equipment and installations include electronic landing aids, navigation equipment, radar and meteorological equipment. The required serviceability of installations and equipment will only be achieved as long as a constant power supply is maintained. To this end, a regular maintenance for airport equipment and installations distributing primary power and equipment supplying the secondary power when there is a circuit break down. This circular will provide a general guideline to the Aerodrome operators in making a maintenance programme for individual elements of the Power Supply System.

3.2 Purpose:

The purpose this manual is to establish a mechanism to assist the aerodrome operators to prepare their maintenance programme for Airport Electrical System and that they effectively implement the aerodrome maintenance programme including preventive maintenance programme to ensure highest level of performance of all kinds of electrical installations and appliances

3.3 Different elements of Electrical Installations and Equipment:

The individual elements of Electrical Installations and Equipment are as follows:-

a. Power cables,
b. Control cables,
c. Airport sub-stations (Transformer, generator, PFI panel, Relay and magnetic circuits, Control circuits, switchgear panels, AVR)
d. Flood lights, street lights, terminal light fittings, fans etc.
e. Boarding bridges,
f. Lifts, escalators,
g. Check-in counters and conveyer belts,
h. Air condition system,

3.4 Maintenance Personnel:

Electricians to be entrusted with the task of maintenance of Airport Electrical System shall have the following qualifications / qualities. They shall-

a. be skilled electricians,
b. be well informed and acquainted with the safety measures while working in high voltage areas,
c. be fully acquainted with the work to be done, and
d. be present or on call during the operating hours of the airport to correct any deficiencies that might develop.

Wherever possible, the same personnel can be utilized for maintenance of both Electrical systems and Visual aids.

Note: *To protect personnel the required safety devices should always be kept in good condition.*

3.5 As-built wiring / circuit diagram and Manufacturer's Manual:

A set of wiring / circuit diagram is required to be available in the maintenance unit. The wiring / circuit diagram shall be kept in the following manner:-

a. A set of wiring / circuit diagram of important and complex electrifications shall be kept readily available.
b. These wiring / circuit diagram must be kept up to date and any changes at site shall be reflected immediately on these drawings.
c. The completeness and the accuracy of all circuit diagrams, drawings and descriptions shall be checked at least annually.
d. Manufacturer's Operation and Maintenance Manual shall be preserved in the office of the concerned maintenance engineering division.

3.6 Spare Parts:

An adequate stock of spare parts should be available. The required level of stock of spare parts will depend on the following criteria:-

a) Rate of consumption of the item;

b) Time required to re-supply the item, and
c) Shelf life of the item.

3.7 General procedures for Maintenance:

At the time of servicing the electrical installations, the following general procedures shall be followed:-

a) The instructions of the appropriate authority, based on the recommendations of the manufacturer shall be followed.
b. Maintenance schedule shall be prepared and records of maintenance of each piece of equipment shall be maintained.
c. These can be arranged in a dated reminder file to make sure that all equipment is serviced regularly.
d. This record should have space to enter observations, measurements and initials of the servicing individual.
e. If situation demands, a change in the schedule may be effected with the approval of appropriate authority and in consultation with the equipment manufacturer, if applicable.

3.7.1 Regular / Corrective maintenance:

Corrective maintenance can be defined as the maintenance which is required to bring an item back to working order when it has failed or worn out. Corrective maintenance shall be carried out on items where-

a) the consequences of failure or wearing out are not very significant, and
b) the cost of corrective maintenance is not greater than preventive maintenance.

Corrective Maintenance activity will consist of repair, restoration or replacement of equipment/ item. This activity will be the result of a regular inspection, which identifies the failure in time for corrective maintenance to be planned, scheduled and effected.

3.7.2 Preventive maintenance:

Preventative maintenance is the maintenance which is carried out to prevent an item failing or wearing out. Preventive maintenance shall be implemented by providing systematic inspection, detection and prevention of incipient failure. Preventive maintenance shall be carried out on items where-

a) the consequences of failure or wearing out are significant, and
b) the cost of corrective maintenance is greater than preventive maintenance.

The items falling under preventive maintenance would be e.g. lift, fire alarms, monitoring lamps for important equipment, electricity supply etc.

3.8 Basic components of maintenance:

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/ Monitoring;
   (The unserviceable lights can be identified more easily during night inspections, and of course, possible failures can be noticed by the operator at the Control desk, if appropriate electric monitoring system is there.)
b. Servicing and overhaul; and
c. Repair.

3.8.1 Regular maintenance and Inspection:

Inspection is a vital part of maintenance. An inspection programme shall be prepared and be strictly followed. As the frequency of inspection will vary according to the hours of operation of the airport, inspection programme shall be prepared keeping pace with the hours of operation of the airport and flight schedule. Inspection programme for residential or commercial areas shall be prepared on different perspectives. Maintenance personnel of supervisor category shall regularly inspect the electrical installations and equipments to assess the requirement of maintenance, and maintenance work shall be done immediately. For expediting the job, maintenance personnel shall be included in the inspection team to do the maintenance job instantaneously.

3.8.2 Recording of Inspection and Maintenance reports:

a. Daily report of the maintenance work during the last 24 hours shall be raised by the maintenance personnel and shall be sent to the concerned Engineer's office. The Engineer shall verify the genuinity of the report and preserve in his office as record.
b. Copy of the report shall be sent by the Engineer to the Airport Manager (Attention: SATO). Airport Manager / SATO shall verify the maintenance report and take necessary action. Significant discrepancies shall be consulted with the concerned engineers. Reports shall be preserved as record.

3.8.3 Inspection and Maintenance Team:

Regular inspections of the Electrical items shall be done with a team consisting of at least 3 (three) members out of the following persons, where No. a, or No. b shall be included:

a. Assistant Engineer, E/M
b. Sub-assistant Engineer, E/M
c. E/M Foreman,
d. Electrician,

3.8.4 Grouping of the electric items for Maintenance:

For the purpose of efficient maintenance and easy supervision all the electrical items may be divided into some groups and maintenance task of particular group of items may be assigned to separate group of personnel. Such grouping may done in two ways:-

a. group of equipment/ installations which are identical in nature, or
b. group of equipment/ installations which are located in one or adjacent areas.

Both the ways of grouping has their merits and demerits, and of course, the concerned aerodrome operator shall decide the way which will be most suitable for his aerodrome.

3.9 Maintenance schedule and frequency of maintenance:

It is very difficult to describe a generally applicable maintenance schedule for the very different types of electrical installations. The frequency of inspection, cleaning and servicing will vary according to the type of installations and equipment, their location and usage. A maintenance programme shall be prepared for each airport based on its past experience and with the objective of achieving required service standard.

The following schedules are presented as guidance material in establishing a corrective and, at the same time, a preventive maintenance programme.

a. More frequent checks may be required for higher categories of lights / equipment.
b. Each check shall be followed by appropriate corrective action.
c. All malfunctions and corrective actions are to be recorded after taking the action.

3.9.1 Daily Checks:

(1) Lighting and Electric equipment, Lighting system of the terminal building and forecourt, Apron Flood lighting, Lighting system for Roads and Parking lots:

a. Burnt-out lamps shall be replaced.
b. Unserviceable switches, including remote control switches, shall be repaired or replaced as required.

(2) Control cables, monitoring units, control desk:

a. Optical and acoustical signals shall be checked for feedback and restored.
b. Unserviceable and burnt-out lamps of monitoring units shall be replaced.

(3) Fixed 400 Hz ground power supplies:

a. Plugs, cables and cable holdings shall be checked and repaired, as required.
b. Unserviceable control lamps shall be replaced.

(4) Lifts / Escalators:

a. Lifts shall be cleaned.
b. Functioning of the lifts shall be checked; any unusual sound or jerk shall be attended and for fault shall be removed.

(5) Air conditioners:

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

a. Moisture control shall be checked.
b Energy consumption of electric motors freezers shall be checked.
c. Cooling water flow meters timer control shall be checked.

3.9.2 Weekly Checks:

(1) Lighting and Electric equipment, Lighting system of the terminal building and forecourt, Lighting system for Roads and Parking lots:

a. Proper functioning shall be checked and ensured.
b. Fluorescent tubes and ignition starters shall be replaced, as required.

(2) Airport sub-stations:

a. Over-all condition of the Sub-stations shall be checked visually and restored.
b. All switchgear panels shall be checked for completeness of contents and missing elements shall be added.

(3) Control cables, monitoring units, control desk:

a. Nominal control voltage shall be maintained by charging the batteries,
b. Voltage and ammeter readings shall be adjusted.
c. Acid level in batteries shall be maintained by adding distilled water.

(4) Fixed 400 Hz ground power supplies:

a. Proper functioning shall be checked and ensured.
b. Loose connections shall be repaired.
c. Necessary repairs shall be done to prevent oil spillage.

(5) Baggage check-in counters, weighing scales and Conveyor Belts:

a. Visual checks shall be carried out for check-in counters, weighing scales and for cuts and cracks of the belts. Short cracks at the edges can be eliminated by cutting off the damaged edge material.
b. Smooth movement and low noise shall be ensured by proper servicing. Noisy and squeaking parts shall be repaired or replaced.
c. Loose spring rollers shall be adjusted.
d. Stress on belt movements shall be adjusted to normal.
e. Control box and monitoring units of the check-in counters and weighing scales shall be checked and repair or replacement shall be done, as required.

(6) Passenger Boarding Bridge:

a. Tires shall be checked for surface damage and wear.
b. Wheel brakes shall be checked.
c. Electric driving motors shall be checked and drive chains shall be cleaned, as required.
d. Lifting jacks shall be checked for normal operations; lubrication shall be done as required.
e. Hydraulic system shall be checked and normal operation shall be ensured.
f. Bridge movements, i.e. extension, retraction, lowering, raising and steering shall be checked and normal operation shall be ensured.

(7) Air Condition system:

a. Activated carbon filters and air filters shall be changed, as required.
b. Energy consumption of freezers (refrigerators), air supplies, fans, electric motors, flaps, valves, regulators and pumps shall be checked.
c. Insulation shall be che4cked damage for damage.
d. Cone belts shall be checked.

3.9.3 Monthly Checks:

(1) Lighting and Electric equipment:

a. Accumulators (battery capacities) shall be checked.
b. Repair work, as found necessary through inspections, shall be done according to maintenance plan.
c. Light bulbs shall be replaced according to maintenance plan.

(2)Transformers and regulators, including stand by units:

a. Shall be cleaned and oil shall be replaced.
b. Regulator switches at all light intensity positions shall be checked and restored.
c. Switch over to standby units shall be checked for serviceability, and restored.

(3) Control cables, monitoring units, control desk:

a. Functions of the monitoring units shall be checked.

b. Parts shall be cleaned, repaired and replaced as required.

(4) Fixed 400 Hz ground power supplies:

a. Serviceability of control lamps shall be ensured by replacement of lamps, as required.
b. Cleanness of cables shall be ensured.
c. Ventilator flaps and orifices shall be cleaned.
d. Stress on the cone belts driving the ventilator system shall be adjusted to normal.

(5) Baggage Conveyor Belts:

a. Joints and dirt trapping boxes shall be cleaned.
b. Papers and other wastes shall be removed from underneath the belts.

(6) Air Conditioners:

a. Servicing of all air ducts, fans, electric motors, flaps, valves, regulators and pumps shall be done.
b. All dirt traps in the pipe network shall be cleaned.
c. Energy consumption record shall be checked; corrective action shall be taken as required.
d. Air ducts shall be checked and cleaned.

(7) Secondary Power Supplies (*Generators*):

a. Switch-over time from primary to secondary power supply shall be checked for conformation to the requirement.
b. Voltmeter readings shall be checked to ensure that the voltage remains within acceptable tolerances.
c. Transfer equipment shall be checked for excessive heating and malfunctions.
d. Diesel engine shall be checked for any irregularities and oil leakage.
e. After the test run, fuel level in the tank shall be checked and refilled with fuel, if required.
f. Corrective repairing action shall be taken for any abnormal or undesirable performance.
g. All the meter readings of the test run shall be recorded and compared with former records to detect potential deficiencies; if required, corrective action shall be taken.

3.9.4 Quarterly Checks:

(1) Control cables, monitoring units, control desk:

a. System components shall be tightened, repaired or replaced, for good connections.
b. Over-all operation of control desk shall be investigated and parts shall be repaired or replaced against malfunctions.
c. Indications of the mimic panel shall be corrected or adjusted for field conditions.

d. Mechanical structure of the desk shall be repaired for stability.

(2) Fixed 400 Hz ground power supplies:

a. Potential deformations of the current-input cables shall be removed.
b. Mechanical damage of the connector boxes shall be repaired.
c. Proper mounting of plug sockets shall be ensured.
d. Bearings shall be lubricated properly.

(3) Lighting and Electric equipment:

a. Lighting control units shall be checked.
b. Dimmers shall be adjusted.

3.9.5 Half-yearly Checks:

(1) Underground Power cables and Control cables:

a. Output level shall be measured, and shall be repaired, as required.
b. Distributors located in manholes shall be cleaned and dried.
c. Plug-in and clamp connections in the distributors shall be tightened and sprayed for good contact.
d. Manholes, for condition of the interior, shall be pumped-out, dried up and cleaned.
e. Insulation resistance shall be measured by measuring the earthing resistance of each circuit, and the readings shall be recorded and necessary corrective actions shall be taken.

(2) Fixed 400 Hz ground power supplies:

a. Cables shall be repaired or replaced to ensure serviceability (wire and insulation).
b. Temperature rise in the main conductor cable under nominal electric power shall be removed by removal of observed deficiencies.
c. Connectors, plugs and cable holdings shall be adjusted and tightened.
d. Switches shall be cleaned of dust and dirt for proper operation.
e. Mounting screws or bolts of the fixings holding the regulator and switch cabinet housing shall be tightened.

(3) Transformer stations for electric power supply:

a. Insulators and electrical connections shall be cleaned and restored.
b. Stations shall be cleaned and dried against dirt and moisture.
c. Locks to stations shall be repaired for serviceability and locking.

(4) Relay and switch cabinets (including switch cabinets in sub-stations):

a. Turn and plug-in connections shall be cleaned to maintain good electrical contact.
b. Relays shall be cleaned to maintain positive closing of contact.

c. Corroded and wearied electrical contacts shall be cleaned, and replaced as required.
d. Cabinet shall be cleaned and dried, weather seals be kept serviceable, and mechanical damages shall be repaired.
e. Relays of series circuits shall be monitored for proper feedback, and repaired as required.
f. Voltage switch-over of two circuits shall be repaired for serviceability, if required.

(5) Secondary power supplies (generators):

a. Switch over time from primary to secondary power supply shall be checked and conformation to the requirement shall be ensured.
b. Voltmeter readings shall be checked and voltage within the acceptable tolerance shall be ensured.
c. Excessive heating and malfunction of Transfer equipment shall be repaired, as required.
d. Any irregularity or oil leakage of diesel engine shall be removed.
e. Fuel level shall be checked after the test run and refueling shall be done, as required.
f. Corrective action shall be taken for any other abnormal or undesirable performance.
g. Meter readings of the test runs shall be recorded compared with former records and corrective actions shall be taken for any potential differences.

(6) Passenger Boarding Bridges:

a. Bearings and their lubrication shall be checked and restored.
b. Rollers shall be checked for wear and corrosion, and shall be greased, repaired and replaced as required.
c. Drive chains shall be checked for stress and shall be adjusted, as required.
d. Floor covers shall be checked for damage and be fixed as required.
e. The outer skin of the tunnel shall be cleaned.
f. Paints shall be renewed.

(7) Air Conditioners:

a. Refrigerators and switching units shall be serviced.
b. Heat exchangers and fans shall be cleaned.
c. Output data shall be verified and performance of all components shall be adjusted to desired standards.
d. Hot air curtains and air filters shall be serviced.

(8) Passenger Communication and Information Facilities:

a. All components of Flight information boards and television monitors, electric clock system and amplifiers for the loudspeaker system shall be serviced.

(9) Lighting and Electric equipment:

a. Supply lines, cables, switches and distributors shall be checked.
b. Plugs, contacts and terminals of the electric wiring shall be cleaned.

3.9.6 Annual Checks:

(1) Lighting and Electric equipment:

a. Lamps shall be cleaned.
b. Insulation capacity shall be checked by overload voltage.

(2) Transformer stations for electric power supply:

a. Relays shall be adjusted.
b. Insulation of high voltage cables shall be recorded and necessary preventive action shall be taken.
c. Earthing and its resistance shall be checked and cleaning / necessary corrective action shall be taken.
d. Noisy and damaged electric supply system shall be repaired.
e. Rusted, corroded and defective coatings shall be cleaned and painted.
f. Warning signs and safety devices shall be cleaned and replaced in correct positions.
g. Safety grids shall be cleaned; coating deficiencies shall be removed and painted against rust.
h. Safety grids shall be tightened for stability and proper earthing shall be restored.

(3) Transformers and Regulators, including stand by units:

a. If noisy, reason shall be found out and repairing action shall be taken.
b. Over-all condition shall be checked and repairing action shall be taken, as required.
c. Insulators shall be repaired and replaced as required.
d. Collector bar system shall be cleaned.
e. Voltage and amperage shall be measured and recorded at all intensity levels, and shall be adjusted to nominal level.

(4) Relay and switch cabinets (including switch cabinets in sub-stations):

a. Cabinets outer conditions shall be well maintained for easy access by cleaning and drying.
b. Fuses and fuse sockets shall be cleaned, sprayed or replaced, if required.
c. Voltage out-put of all series circuits shall be recorded and necessary corrective actions shall be taken.

(5) Control cables, monitoring units, control desk:

a. Cables and distributors shall be cleaned and repaired.
b. Relays shall be cleaned.
c. Control and monitoring units shall be replaced, as required.
d. Connections shall be tightened and sprayed for good contact.

(6) Baggage Conveyor Belts:

a. Drives shall be checked and overhauled, as required.
b. Driving motors shall be cleaned.
c. Gear box oil shall be changed and refilled.
d. Driving chains shall be cleaned and lubricated.

(7) Lifts / Escalators:

a. Ropes, drives and other moving parts shall be completely overhauled.

(8) Escalators:

a. Total system shall be completely overhauled.

(9) Air conditioners:

a. chemical and mechanical cleaning of condensers and evaporators.
b. servicing of fire protection gates.

(10) Passenger Communication and Information Facilities:

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

(11) Apron Flood lighting:

a. Turn and plug-in connections shall be cleaned for good electric contact.
b. Relays shall be maintained serviceable by cleaning, repair or replacement.
c. Corroded and wearied contacts shall be cleaned, repaired or replaced.
d. Cabinet shall be cleaned and dried, weather seals be kept serviceable, and mechanical damages shall be repaired.
e. Fuses and fuse sockets shall be cleaned, sprayed or replaced, if required.
f. Cabinets outer conditions shall be well maintained for easy access by cleaning and drying.

3.9.7 Non-schedule Checks:

In addition to carrying out all the above mentioned scheduled maintenances, situations like some natural calamity, accidents, sabotage etc. may give rise to the necessity of some out-of-schedule maintenance. Some instances of such non-schedule maintenance are as follows:

(1) Underground Power cables and Control cables:

a. Underground Power cables and Control cables, whenever malfunction is observed, shall be repaired.

(2) Control cables, monitoring units, control desk:

a. After each lightning strike, the insulation between wire & wire, and between wire & ground shall be checked and necessary improvement shall be effected.

(3) Control cables, monitoring units, control desk:

a. After each lightning strike, the insulation between wire & wire, and

(4) Air conditioners:

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.

Chapter 4. Maintenance of Paved areas of the Airport

4.1 Introduction

For safe operation of aircraft in an airport, a safe runway is an essential requirement. 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. At the same time the pavement areas of an airport is to maintained free from slipperiness so that the braking action of aircraft is not affected. This specification requires continuous monitoring of pavement condition, and repair servicing whenever 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.

4.2 Different Paved areas of the Airport:

Different Paved areas of the airport are as follows:-

a. Runways,
b. Taxiways,
c. Apron,
d. Cargo handling areas,
e. Shoulders, etc.

4.3 Maintenance Personnel:

Personnel to be entrusted with the task of maintenance of Airport paved areas shall have the following qualifications / qualities:-
They shall be-

a. Experienced in concrete and bitumen pavements;
b. Fully acquainted with the work to be done;
c. Present or available on call whenever required;

4.4 As-built drawing:

A set of 'as-built drawing' is required to be available in the maintenance unit. The as-built drawing shall be kept in the following manner:-

4.5 Basic Components of Maintenance:

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 / repair and
c. Replacement.

4.6 Inspection and Maintenance team:

Inspection is a vital part of maintenance. An inspection programme shall be prepared and be strictly followed. As the frequency of inspection will vary according to the hours of operation of the airport, inspection programme shall be prepared keeping pace with the hours of operation of the airport and flight schedule. Maintenance personnel shall regularly inspect the paved areas to assess the requirement of maintenance, and maintenance work shall be done immediately.

4.6.1 Responsibility of inspection:

The responsibility of inspection of pavement areas of the airport shall be given to a committee formed with at least two members out of the following three:

a. Assistant Engineer, Civil,
b Sub-assistant Engineer, Civil,
c. Foreman.

4.6.2 Responsibility of maintenance:

The responsibility of maintenance shall lie on the concerned Engineering divisions.

4.6.3 Recording of Inspection and Maintenance reports:

a. Reports of the maintenance work during the last 24 hours shall be raised by the maintenance personnel and shall be sent to the concerned Engineer's office. The Engineer shall verify the genuinity of the report and preserve in his office as record.
b. Copy of the report shall be sent by the Engineer to the Airport Manager (Attention: SATO). Airport Manager / SATO shall verify the maintenance report and take necessary action. Significant discrepancies shall be consulted with the concerned engineers. Reports shall be preserved as record.

4.7 Joints in Cement Concrete:

4.7.1 Necessity of Joints in Cement Concrete:

Joints are provided in concrete pavements to eliminate stress induced by length variation of the concrete materials due to temperature changes.

4.7.2 Closing (sealing) of joints in concrete slabs:

Joints may be closed with fuel resistant elastic materials, like

a. Bituminous sealant, or
b. Hose type elastic sealant (Neoprene profile sealing).

4.7.3 Why joints between concrete slabs are required to be closed:

Joints are required to be closed because otherwise,

a. Surface water may penetrate into the sub-base or sub-grade, and

b. Hard debris or stones may be pressed between adjacent concrete slabs.

4.7.4 Damage of joint sealing in concrete slabs:

The first sealant of a concrete joint is expected to remain serviceable for a period of 4 to 6 years depending on the mechanical and thermal impact on the pavement. Later on due to the -

a. partial loss of original elasticity, and
b. shrinkage of the sealing material, it will fail to adhere to the side flanks.

At that stage, mechanical forces applied to such aged sealant will start the sealant breaking off, and rotary brooms of sweeping will accelerate the process.

4.7.5 Effect of joints in concrete slabs being permeable :

Once a joint becomes permeable then,

a. The sub-grade may be washed out, and
b. Voids below the slabs may weaken the capability of the base material.

This effect will result in destruction of the concrete. Basically, the sensitivity of the sub-grade to water determines the requirement of maintenance of the joints.

4.7.6 Protection of Concrete pavements from severe damage:

In order to protect the concrete pavements from severe damage, renewal action shall be taken whenever the joint sealing is observed to fail and break off.

4.7.7 Concrete joint maintenance:

4.7.7.1 Repair of concrete slab joints shall be done as follows:-

a. All old sealing material shall be removed. A so-called "joint plough" may be used to carry out this task.
b. Then the bare slab flanks shall be cleaned thoroughly of soil, grease and dust.
c. Where edges are damaged they shall be repaired with a suitable synthetic resin grout.
d. After inserting a new inlay to limit the depth of the sealing material, the joint may be refilled with the liquid sealing material.
   Attention: Attention shall 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.
e. The selected material must be fuel-resistant, particularly in pavement sections where fuel spillage may occur occasionally.

4.7.7.2 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 following procedure shall be followed:-

a. The concrete flanks shall be covered with an adhesive before placing the sealing profile into the joint.
b. At joint intersections and ends the plastic material must be welded together to prevent water entering at the insert and it acting as a hose distributing water to the entire joint system.

4.8 Cracks and damage of Cement concrete:

4.8.1 Cause of cracks in cement concrete:

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 sub-grade so that slabs are not supported equally;
e. Insufficient dimensioning of concrete slabs in view of the load applied on them.

4.8.2 Repair of cracks in cement concrete:

4.8.2.1 "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 sub-grade.

4.8.2.2 Cracks in concrete slabs shall 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 scaling material.

4.8.2.3 When the sub-grade is particularly affected by water and optimum water tightness is required, the repair process shall be as follows:-

a. A channel about 20 cm wide and 2 cm deep shall first be cut along the track of the crack.
b. Then the crack shall be widened to a slot as described in the preceding paragraph.
c. The cleaned slot shall be filled with a dummy insert.
d. Then, after appropriate cleaning and priming, the channel shall be filled an epoxy resin grout.
e. When the resin has hardened, the insert shall be removed from the widened crack and the resulting void filled with a fuel resistant thermoplastic sealing material.

4.8.3 Types of damage of Cement concrete:

a. Porous and disintegrated surfaces,
b. Separation of thin top surface layers,
c. Braking up of the pavement where cracks extend to inner layers,
d. Extreme polishing of surface created by polishing under traffic etc.

4.8.4 Cause of damage of cement concrete:

a. Insufficient cement,
b. Improper quality of aggregates,
c. Segregation during placement,
d. Evaporation,
e. Abnormal temperature,
f. Too high water content,
g. Improper treatment during hardening.

4.8.5 Repair of damage of cement concrete:

4.8.5.1 Where the damaged layer is very thin:

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 thereby 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.

4.8.5.2 Where the surface is too porous:

Where the surface is 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 sealings, the forming 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. Further-more, the surface will become too smooth and slippery when wet.

4.8.5.3 Where surface material is severely damaged with deep cracks:

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.

4.9 Joints in Bituminous Pavements:

4.9.1 Necessity of Joints in Bituminous Pavements:

Recent experience shows that it is useful to provide 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 which is very likely to occur in bituminous pavements due to thermal stress may be avoided by providing joints in bituminous surfaces.

4.9.2 How to provide joints in Bituminous Pavements:

4.9.2.1 Stress reliever joints not wider than 8 mm and not deeper than 2/3 of the thickness of the wearing course may be cut into the pavements 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.

4.9.2.2 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.

4.9.2.3 Where joints in bituminous pavements are damaged they normally can be repaired by filling with a hot bituminous 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.

4.10 Cracks in bituminous pavements:

4.10.1 Cause of cracks in bituminous pavements:

Causes for cracks in bituminous pavements can be as follows:

a. Thermal stress building up in vast pavement areas when there no expansion joints;
b. An insufficient adhesion of construction joints between adjacent lanes;
c. Deficiencies of sub-grade bearing strength at isolated points due to construction mistakes so that slabs are not supported equally.

4.10.2 Repair of cracks in bituminous pavements:

a. The cracks shall be properly cleaned before filling.
b. Cracks can be filled with a sealing emulsion without prior grinding;
c. The filling can be carried out manually by using cans, or mechanically by using special pouring equipment;

d. At first the crack's interior flanks shall be covered, and then in the second run the cracks shall be filled up.
e. The procedure shall be repeated yearly or at longer intervals, depending on local climatic conditions.

*(**Note:** Special emulsions of high fluidity are available that will penetrate deeper into the crack than hot bituminous sealing.)*

4.11 Damage of bituminous pavements:

4.11.1 Types of damage of bituminous pavements:

The damage of bituminous surfaces can be broadly classified in the following way:-

a. Damage is minor and affects the surface only,
b. Damage is slightly deeper and affects more than the surface layer,
c. Damage goes deeper and affects up-to the base layer.

4.11.2 Cause of damage of bituminous pavements:

The cause of damage of bituminous surfaces can be broadly classified in the following way:-

a. Wrong composition of the bituminous mixture,
b. Impact of fuel, grease or other chemicals or solvents,
c. Extreme spot loading,
d. Mechanical wear,
e. Decay by weathering of the surface structure,
f. Softening of the surface and deformation.

4.11.3 Repair of damage of bituminous pavements:

4.11.3.1 When the damage is minor and affects the surface only:

Bituminous seal, onto which quartz sand or crashed basalt material is spread, shall be sprayed and rolled. Good engineering practice shall be applied.

4.11.3.2 When the damage is slightly deeper and affects more than the surface layer.

a. The whole affected layer, up-to a depth of minimum 3 cm, shall be removed by grinding.
b. After grinding the strips shall be carefully cleaned from contamination and grinding materials.
c. After cleaning, a bituminous binding layer shall be applied.
d. Then the new bituminous layer shall be brought in and rolled for compaction.
e. Compaction shall be carried out very thoroughly at the edges of the old asphalt in order to close the joints.
f. The bed of the new layer shall be sharply edged to receive a clean seam.
g. Covering the joints by spraying with a bituminous seal is recommended.

4.12 Pavements Edge damage:

4.12.1 Cause of Pavements edge damage:

a) Undesirable transfer of force across the joint mostly produced by incorrect joint design.
b) Stones pressed into the joints.
c) The pavement material above the point of contact is split off due to the induced compressive stress.
d) Application of extreme point loads near to a slab joint or slab edge.
e) Corners are particularly sensitive to overload when for some reasons the slabs get insufficient support from the sub-base.

4.12.2 Risks of Pavements edge damage:

a) Broken edges produce loose parts of various sizes which create a substantial risk to aircraft.
b) Furthermore, surface irregularities on pavement are undesirable for aircraft and ground vehicles.

4.12.2.1 Immediate Remedial action:

Broken edges shall be repaired as soon as possible. At least, imminent danger to aircraft shall be minimized by-

a. Removing all loose material from the pavement surface, and
b. Provisionally closing the deeper openings in the pavement surface.

4.12.3 Repair of Pavements edge damage:

Repair of damaged pavement edges shall be done as follows:-

a. Primarily careful investigation of the damaged section shall be carried out to find out the reason for the failure.
b. To start the repair, the treated area shall be made big enough to cover all damage.
c. The boundary shall 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.
d. 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.
e. No bridge shall be built up between the two neighboring slabs, since sooner or later it would become the source of a new break in the repaired edge.
f. The joint's flanks shall be cleaned, and dust and debris removed from the opening, preferably by compressed air.
g. After preparing the cut surface with a primer, a form shall be put into the emptied joint.
h. After hardening, the form in the joint shall be removed, flanks in the joint cleaned, and the joint shall be filled with a hot sealing material.
i. Compacting shall be done layer by layer and when smoothing the surface a chamfer should be provided at the edge.

j. A filler material shall be chosen such that it meets the requirements of the climatic impact on the airport's pavement.
k. Filler material which obtains its nominal strength no sooner than 24 hours after mixing has proven to be more suitable than quick hardening material.
l. Sufficient aggregate (quartz, glass pearls or other ceramic) shall be to achieve a lean mixture with a small shrinkage ratio.

4.12.4 Repair of broken corners:

Broken corners shall be repaired in the same way as described for edge repair. Attention shall 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.

4.13 Preventative Maintenance of Asphalt Pavements:

4.13.1 Components of pavement preservation system:

There are three components of a pavement preservation system:

a. preventive maintenance,
b. minor rehabilitation, and
c. routine maintenance.

One method of preventative maintenance is the use of pavement sealers, which in turn makes minor rehabilitation and routine maintenance easier. Pavement sealers are applied to do the following functions:

a. to protect the surface of Hot Mix Asphalt (HMA) pavement from the corrosive effects of gasoline, diesel oil, motor oil, and grease that drip or are spilled onto an asphalt-based surfaces; and
b. to prolong the life of asphalt based pavements by decreasing oxidation (that occurs via exposure to air) and ultraviolet light bleaching (that occurs via exposure to sunlight) as well as preventing moisture from entering the pavement.

4.13.2 Effect of Preventative Maintenance of Asphalt Pavements:

The net effect is an extension of the performance life of new or existing asphalt-based pavement.

4.13.3 Study result on Preventative Maintenance of Asphalt Pavements:

A study by the Washington State Department of Transportation (DOT) contains the following conclusion (taken from internet):

An effective pavement preservation program integrates many preventive maintenance strategies and rehabilitation treatments. The goal of such a program is to extend pavement life and enhance system-wide performance in a cost-effective and efficient way. Studies show that preventive maintenance is six to ten times more cost-effective than a “do nothing” maintenance strategy layers and helps preserve the structural integrity as well as maintain a smooth ride.

After several years, a thin overlay may be needed to address weathering or drying out of the pavement surface. Costs for this type of maintenance range from $40,000 to $50,000 per 1,000 feet.

If the preventive maintenance program over a 20-year period included three crack-sealing projects and a 2-inch overlay, the airport owner would have spent approximately $325,000 for maintenance; at the end of the 20 years, however, the pavement would still be in good condition. Reconstruction might not be needed for many years.

Without maintenance over a 20-year period, total reconstruction may be needed, at an estimated cost of about $140,000 to $315,000 per 1,000 feet. That same runway would cost anywhere from $750,000 to $1,375,000 to replace. The costs of a "*no maintenance strategy*" are *at least two times higher* in this simple case study.

4.14 Repair of Deficiencies of Pavement surfaces:

4.14.1 Quality requirements of the movement areas:

High quality requirements have been specified for runway pavement surfaces, such as:-

a) The surface texture shall provide good friction characteristics, and

b) The runway surface shall be constructed without irregularities that could adversely affect the landing or take-off of an aeroplane.
(Ref: Annex 14, Attachment A, Section 5, and the Aerodrome Design Manual, Part 3.)

4.14.2 Maintaining the friction characteristics of runway pavement surfaces:

Where the friction characteristics of the runway surface have been found to be below the level specified by the State, 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 surface.

Details on these methods for improving runway surface texture are given in the *Aerodrome Design Manual, Part 3, Chapter 5.*

4.15 Unevenness of surface with aging:

With time 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.

4.16 Contamination of the Movement area and remedial actions:

4.16.1 Objects contaminating the Apron area:

Aprons are more likely to become contaminated than other aircraft movement areas on 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.

4.16.2 Sources of Contamination:

Runway and taxiway contamination is mainly caused by objects stemming 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.
h. fuel, lubricants, hydraulic oils, marking paint or rubber.

4.16.3 Effects of Contamination:

For 6safety reasons the surfaces of runways, taxiways and aprons have to be clean of sand, debris, stones or other loose objects. As such, movement areas require constant monitoring and regular sweeping of surfaces. Otherwise the following accidents may happen:–

a. Aircraft engines can easily ingest loose material, and suffer severe compressor blade or propeller damage.
b. Propeller or jet engine blast may cause loose objects to be "shot" like bullets against adjacent aircraft, vehicles, buildings or people.
c. Tread on tires of taxiing aircraft or any other moving vehicle may throw up objects and cause damage.
d. Contaminants like oil and rubber deposits on runways may cause slipperiness and adversely affect the braking action of aircraft, particularly when pavements are wet.
e. Contaminants cover surface markings creating problems for aircraft movement. A clean runway surface, therefore, is a safety requirement. (Ref: Annex 14, chapter 10)

4.16.4 Removal of Contamination:

4.16.4.1 Visual checks on Movement area:

Visual checks shall be carried out regularly as indicated below:

a) At least every six hours during operating periods.
b) Immediate checking shall be done when pilots report on the existence of objects or debris.
c) Special attention shall be paid to the cleanness of runways and taxiways, when construction works on or near operational surfaces is going on.
d) When construction machines or trucks use surfaces which are used by aircraft, more frequent checking shall be done.
e) Inspection tours or walks shall 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.
f) Through training programmes and regular reminding, personnel working on the apron can be taught to watch and visually check the condition of the apron and report on cleaning needs.

4.16.4.2 Sweeping the movement area:

Surfaces intended to be used by aircraft and ground vehicles have to be swept regularly. The frequency of cleaning / sweeping shall depend 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.

4.16.4.3 Removal of Fuel and Oil:

Contamination by fuels, lubricants and oils can be found on 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 accidently the spillage must immediately be covered by oil-absorbing material, as developed by the oil industry. This material is a powder or granulates which, 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.

4.16.5 Cleaning equipment:

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

4.16.6 Personal 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 the foreign object damage low when the whole staff takes notice of the problem and keeps the movement area as clean as possible.

4.17 Rubber deposits on the Runway:

4.17.1 Sources of Rubber deposits:

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.

4.17.2 Effects of Rubber deposits:

The effects of rubber deposits on the runway are as follows:-

a) Rubber deposit on the runway surface blocks the drainage under the wheel in wet conditions by filling the grooves in the pavement.
b) Rubber deposit makes the runway slippery and affects the braking action of aircraft in wet condition.

4.17.3 Aim of removal of rubber deposits:

The aims of rubber removal from runway surface are the following:

a. to restore the original macro roughness of the pavement surface;
b. to provide good drainage under the wheel; and
c. to restore braking action of aircraft in wet conditions.

4.17.4 Methods of removal of rubber deposits:

Three methods of removing rubber deposit are described below:

a. Mechanical grinding,
b. Chemical method,
c. High pressure water blast.

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

4.17.4.1 Mechanical grinding:

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. 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.
The 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.

4.17.4.2 Chemical method:

In the Chemical method, chemicals dissolve not only rubber but also paint markings and bituminous material, and as such, there is high possibility of erosion of the bituminous pavement, and the markings shall be required to be repainted after each cleaning.

4.17.4.3 High pressure water blast method:

Where 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.

4.17.5 When shall the rubber deposits be removed:

Rubber deposits shall be removed from runways when friction measurements under wet conditions indicate significant loss of braking quality in critical runway sections.
(Ref: Annex 14, Art. 9.4.7. and Airport Services Manual, Part 2 - Pavement Surface Conditions.)

Chapter 5: Drainage of the Airport

5.1 GENERAL:

Drainage of the airport is essential for the following major reasons:

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.

Surface drainage is required to –

- Clear all parts of the movement area of standing water; and
- Prevent the formation of ponds or puddles.
- Quick run-off of water is particularly important on runways to minimize the hazard of aquaplaning.

(Ref: *Airport Services Manual,* Part 2)

5.2 Lay out:

5.2.1 Two drainage systems:

For practical reasons an airport should have two drainage systems-

a. One system which drains "`clean" areas such as runways, taxiways, aprons, service roads, public roads and parking lots; and

b. 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.

5.2.2 Drainage for the clean areas:

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.

5.2.3 Drainage for the areas likely to be polluted:

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 pre-treatment the collected drain water should pass through fuel separators before entering the sewage culvert.

5.2.4 Compliance with national or local regulations:

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 programme.

5.2.5 Cleaning of slot drains:

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. Where necessary, mud and sand deposits must be vacuumed off by special mobile cleaning equipment.

5.2.6 Time intervals for cleaning slot drains:

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.

5.2.7 Drain pipes or culverts between surfaces and collector basins:

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

5.2.8 Time intervals for cleaning drain pipes or culverts:

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 are less than 30 cm, cleaning **twice a year may be necessary**.

5.2.9 Oil and fuel separators:

Oil separators are integral parts of water collectors. Those are components of the drainage system of hangars, workshops and other technical working areas which must be provided with separator installations. 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. Their capacity will be determined by the expected maximum drain water through-put.

5.2.10 Cleaning the oil and fuel separators:

The oil layer depth at the surface of the separator **must be checked weekly** and oil pumped off when necessary. 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.** They 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.

5.2.11 Cleaning the bottom and banks of the drain water collector basins:

The bottom should be cleaned **at least once a year**. The bottom and the banks of the drain water collector basins should be kept clear of plants. Embankments should be mowed regularly.

5.2.12 Removal of oil and fuel from separators:

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.

5.3 Water Hydrants:

5.3.1 Airport's water supply system:

The capacity of the airport's water supply system should comply with the requirements of fire fighting. 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,

5.3.2 Airport Fire hydrants:

All fire hydrants including those at buildings must be checked regularly. Any subsurface hydrants should be kept clean of soil or mud so that they can be found without delay in cases of emergency. Serviceability of pumps and hydrants shall be checked at least twice in a year.

Chapter 6: Maintenance of Unpaved Areas of the airport

6.1 GENERAL:

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 grass land within the airport's boundaries).

6.2 Reasons for maintenance of Green Areas on an Airport:

The major reasons for maintenance of green areas of an airport are as follows:

a. To control animal life within the airport boundary to reduce the risk of animal strike with aircraft;
b. To control the bird population and bird activities in order to keep the bird strike hazard as low as possible.
c. To fulfill the requirements of obstacle clearance limitations.

6.3 Who can do the job:

The responsibility of maintenance of unpaved areas of the airport lies on the aerodrome operator. Of course, that does not necessarily mean that the work is to be carried out by the staff of the airport operator. The airport operator may contract with nearby farmers who can do the job on the following conditions:-

a. The contractor shall do the work upon advice.
b. The contractors shall provide their own equipment.
c. The contractor can use the grass for cattle feed.
d. Work performed by contractors must be monitored by authorized personnel to safeguard air traffic safety requirements.

6.4 Maintenance of Green Areas within strips:

6.4.1 Target of maintenance of Green Areas within strips:

The targets of maintenance of the green areas of the airport are as follows:

a. Bearing capacity of the strips shall be maintained.
b. Evenness of the strips shall be maintained.
c. The height of grass of the strips shall be maintained such that it does not exceed 10 cm.

6.4.2 Procedures for maintenance of Green Areas within strips:

After construction work in strip areas, attention should be paid to retain the specified surface conditions. This can be done in the following manner:

a. Where the bearing capacity has been reduced it must be improved by soil compaction.
b. Humps and depressions shall be eliminated.
c. To protect the surface against blast erosion a sound matting of grass should be provided.
d. The grass should be mowed down to a height of about 10 cm.
e. Regular mowing will be necessary to keep the grass low, the frequency depending on the climate.
f. The cut material should be picked up since otherwise it might be sucked into jet engines, thus creating a potential hazard to aircraft operation.
g. Mowing attracts birds as the freshly mowed areas are rich in bird food.
h. To minimize the ever-present risk of bird strikes, mowing should take place preferably before periods of lowest air traffic.
i. In other cases, bird protection measures shall be increased after mowing to keep the collision risk low.

6.5 Maintenance of Green Areas outside strips:

6.5.1 Target of maintenance of Green Areas outside strips:

The targets of maintenance of the green areas of the airport outside strips are as follows:

a. The height of grass outside the strips shall be maintained such that it does not exceed 20 cm.
b. The obstacle clearance criteria of the area shall be maintained.

6.5.2 Procedure for maintenance of Green Areas outside strips:

a. Maintenance of grass surfaces should be determined by the individual needs of the site, i.e. the local species of birds and their habits.

b. Most species of birds prefer low grass areas for food searching; conditions for finding food are better and watching out for enemies is facilitated by good visibility in all directions.
c. For keeping large numbers of birds from settling, the optimum grass height has been observed to be around 20 cm. Only the smallest birds of body mass less than 20 g will prefer such meadows for residence. They are, however, less dangerous for aircraft than heavier birds.
d. Dry grass-land offers more food to birds than wet land. Therefore, unless bearing capacity of the runway and taxiway is not at risk, swampy patches can be tolerated as long as those do not attract aquatic birds.
e. The grass should be mowed down to a height of about 20 cm and the cut grass should be picked up. Composting effects cut grass produce great numbers of microscopic organisms, insects, worms etc., and again, attract birds to the area.
f. Special methods shall be applied, along with the maintenance of grass, to diminish the number of mice. Where mice population exceeds a "normal" rate, birds of prey may be attracted which, due to their flight techniques and body mass, create the most severe bird strike hazard. Mice populations will then have to be controlled by using suitable chemicals.
g. Trees and bushes shall be cut at such a height that they do not penetrate the obstacle limitation surface. To discourage birds from settling, all bushes carrying berries should be eliminated from the airport.
h. The height of trees in the approach and departure areas outside the airport boundary must be controlled for air traffic safety reasons. To minimize the extent of cutting or shortening of trees, cutting can be done more frequently.

6.6 Equipment for Maintenance of Grass:

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.

6.6.1 Spindle mowers:

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 favourable conditions the capacity can be 7 hectares per hour. Separate loaders are required to pick up the cut grass.

6.6.2 Cutter bar mowers:

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 1/2 hectare 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.

6.6.3 Rotary mowers:

Rotary mowers are specialized on 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.

6.6.4 Flail mowers:

The 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.

6.7 Cost and Benefit:

Capital and operating costs of the different types of mowing equipment vary widely, 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.

6.8 Treatment of cut grass:

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. As to the procedure for reprocessing or disposal of the cut grass, three options exist:

a. Giving away the cut grass to nearby farmers or ranchers;
b. 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;
c. Disposing the grass 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. Disabled Aircraft Removing Equipment

7.1 Removal Plan:

When a disabled aircraft is on a part of the airport where it interferes with the movement of other aircraft, it has to be removed as quickly as possible. Aircraft removal is a rather complex procedure touching quite a number of responsibilities of different parties.

The relevant parties are:

a. Aircraft registered owner,
b. National authority for air safety and accident investigation (CAAB),
c. Airport operator (Airport Management),
d. Owner of removal equipment (CAAB, Army, BAF, BDFS etc.) and
e. Maybe others.

7.1.1 Removal Procedure:

The procedure has to be performed in compliance with the removal plan worked out for the airport to satisfy local circumstances.

Reference is made to:-

a. Annex 14, 9.3;
b. *Airport Services Manual,* Part 5, Guidance material on the establishment of the removal plan, procedures, techniques, methods and equipment;
c. *Airport Services Manual,* Part 8 -- Airport Operational Services. Removal of Disabled Aircraft and operation of the disabled aircraft removal service.

7.2 Personnel Training:

Regardless of how removal responsibility and removal performance is agreed, staff should be trained thoroughly to handle the available equipment in the event of an aircraft removal.

7.2.1 Training programme:

The personnel assigned to the task of aircraft removal should at first be given a detailed and specified training, and there after recurring training programme should take place at least once a year.

The programme has to include-

(i) instruction on theoretical measures,
(ii) methods to be applied, and
(iii) practical training in handling the equipment.

It should be continuously updated according to the most recent knowledge and experience available on aircraft removal techniques.

7.3 Storage of Equipment:

7.3.1 Where to store:

The location where all removing equipment will be stored should have the following advantages:-

a. All removal equipment shall be stored at one location, if possible.
b. The store units shall be designed for easy transport and loading.
c. Equipment shall be stored in such a manner as to minimize the risk of damage by equipment and vehicle movements.

7.3.2 How to store:

Only careful storage and regular inspection can ensure that the equipment will be in good condition and that any aircraft removal operation will be successful and expeditious. Furthermore, proper storage and maintenance will extend the life of the equipment, which is important from an economical aspect.

The following cautionary system shall be followed while storing the equipment:-

a. Equipment should be stored in a manner to ensure quick access at any time.
b. As far as possible, equipment shall be stored in transportable units. This not facilitates access in cases of a removal action but also for equipment inspection and maintenance procedures.
d. Equipment packed in boxes or on pallets shall be protected from the effect of weather such as wetness, moisture, heat, sunshine (ultraviolet radiation) which may rapidly destroy wooden, textile, plastic or rubber material.
e. In order to protect equipment from detrimental climatic conditions, no material should be stored close to the equipment which would cause damage to it.
f. In all possible cases, equipment shall be wrapped to protect from contamination.
g. Wooden material, e.g. plywood sheets and cribbing timber, has to be stored flat to avoid warping.
h. All steel material needs an oil or paint finish to protect against rust.
i. Protection must also be taken against vermin (mice, rats, termites, etc.).
j. Each unit shall be clearly marked for quick identification of the contents.
k. All pieces of the stored equipment shall be listed. The list should identify their location within the store and show the maintenance needs.

7.4 Transportation plan of equipment:

A transportation plan shall be prepared that shows which vehicles are to be used for the transportation of removal equipment and how the vehicles are to be available in the event of an aircraft removal action.

7.5 Inspection of equipment:

Regular inspection of all equipment is recommended to ensure that the equipment sets are complete and serviceable at all times. Inspection shall be carried at least once in a month, and necessary action shall be taken.

7.6 Maintenance of removal equipment:

Many of the pieces of equipment may need maintenance work at periodic intervals. All regular maintenance work shall be carried out in accordance with the manufacturer's advice. Discovery of damage or deficiency should lead to immediate repair.

A general guideline on the Maintenance Schedule is given below:

7.6.1 Monthly Checks:

(1) Air Compressor units:

a. Air compressors shall be subjected to a test run of at least five minutes once in a month. The following checks shall also be done.
b. Tire pressure shall be checked.
c. Oil content (compressor unit and engine) shall be checked.
d. Diesel content of tank shall be checked.
e. battery capacity and acid content shall be checked.
f. cooling water content shall be checked.
g. any other technical details in accordance with the manufacturer's advice.

(2) Drainage pumps, flood lights and diesel generators:

a. Remedial action shall be taken for mechanical damage, oil and fuel leakage.
b. Battery capacity and acid content shall be checked.
c. Fuel and oil content shall be checked,

7.6.2 Half-yearly Checks:

(1) Protection pads (foam rubber pads) which are used to protect the lifting bags:

a. Protection pads shall be checked and maintained in good condition through repair or replacement, as required.

(2) Air hoses:

a. Air hose shall be checked for integrity and cleanness.

(3) Hydraulic jacks:

a. Hydraulic jacks shall be inspected in conjunction with a test run at which time the equipment shall be checked for corrosion, oil leakage or any damage in accordance with the manufacturer's advice.

(4) Winches, cables and ropes:

a. Winches, cables and ropes shall be checked for mechanical damage.
b. Special attention shall be given to bends and corrosion of steel cables and other load bearing lifting equipment.
c. Stress tests shall be carried out in accordance with relevant safety and/or manufacturer's advice.

(5) Additional equipment consisting of:

-Plywood sheets,
-Steel and aluminum plates,
-Cribbing timber,
-Steel spikes for crib assembly,
- ground reinforcement mats (trackways or other),

- earth anchors, copperloy coated steel grounding rods, cables and clips,

- fencing material and warning signs,

-tools such as bolt cutters, sheet metal shears, picks, shovels, crow bars, hammers and saws

a. Shall be checked for completeness and proper condition.

b. damage like corrosion, cracks, distortion or wetness shall be repaired or replaced, as required.

(6) Pneumatic lifting bags:

a. Checks shall be done whether bag material has suffered from detrimental storage conditions such as high heat, direct sun radiation or wide temperature variations.

b. The maintenance programme for lifting bags should include:
   -Cleaning of contamination, if required;
   -Inflation up to the checking pressure as indicated by the bag manufacturer;
   -Repair of all deficiencies or damage;
   -Correct preparation for storage, i.e. dry surfaces, air valves protected by caps, surface powdered with French chalk;
   -Wrapping of folded bags to transportable packs.

7.6.3 Yearly Checks:

(1) Air Hoses:

a. Air hoses should be stored on hose reels.

b. The hoses must be unwound from their reels and stretched out on clean ground.

c. A functional test can be accomplished by connecting them to the console module and applying air pressure. This procedure allows a check for any damage and the serviceability of all connections.

d. Hoses shall be kept clean inside and outside to protect the rubber material.

e. Ends of the hoses shall be closed by caps and reels shall be covered.

f. Any deficiencies discovered shall be made good by repair or replacement.

(2) Console module:

a. Maintenance work shall include checking for-
   -Integrity;
   -Damage to any component;
   -Serviceability of valves and stopcocks (function test under pressurized air according to manufacturer's advice);
   -Function of pressure gauges.

7.7 Test Run of the Equipment:

A Test Run should be held once in a year as a part of the Maintenance Programme. In addition, a rolling test should be carried out every six months to check wheel brakes and lamps of the vehicle.

Chapter 8. Maintenance of Equipment and Vehicles

8.1 General:

8.1.1 RFF Operation vehicles:

Vehicles which are essential for the safe and smooth operation of aircraft at an airport shall be kept serviceable at all times through preventive and corrective maintenance. 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. As per Annex 14, Art.9.4, the following equipment and vehicles of an aerodrome are related with the safe operation of an airport:

a. Rescue and fire fighting vehicles;
b Sweepers for removal of contaminants from aircraft operating areas;
c. Mowers and other vehicles for control of grass height on unpaved areas.

8.1.2 Passenger, Freight and Ground handling vehicles:

There are many other vehicles also 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 full time serviceable as part of the airport maintenance task.

8.2 Principles of organization of maintenance of vehicles:

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

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

8.2.1 Reasons for providing workshops at the airport:

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.

8.2.2 Reasons for providing airport-owned workshops:

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 aircraft removal, assistance in emergencies, etc. can be assigned to workshop personnel upon short notice.

8.2.3 Reasons for contracting with maintenance companies outside the airport:

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 auto-motive 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.

8.3 Schedule of Vehicle Maintenance:

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 shall be based on experience with maintenance needs.

8.3.1 Basis of preparing the Vehicle Maintenance Schedule:

The different types of vehicles of an airport do not run at the same rate or distance. Some of them are operated everyday and run quite good number of kilometers, some do not undergo long runs, though operated for long hours, while there are equipment which are often given static runs only. Thus their maintenance requirement and schedule will also vary. On the basis of that the vehicles and equipment can be grouped into the following categories for maintenance:

a. Schedule on the basis of kms run.
b. Schedule on the basis of hours operated.
c. Time based schedule i.e. on the basis of Months or year.

8.3.1.1 Schedule on the basis of kms run:

Self driven vehicles like standard cars, station wagons, microbuses, buses, Ambulances etc. which more or less run considerable number of kms regularly should fall under the schedule on the basis of kms run. User or operator of the vehicle must maintain record of the kms run. This can be done by marking the next milometer reading when the maintenance shall be due.

8.3.1.2 Schedule on the basis of hours operated:

Vehicles or equipment like RFF vehicles, standard trucks, aircraft towers, runway sweepers, mowers etc. which, although operated regularly for considerable hrs. do not run considerable number of kms should fall under the schedule on the basis of hours operated. User or operator of the vehicle must maintain record of the hours of operations. This can be done by marking the next milometer reading when the maintenance shall be due. 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 fuelling personnel.

8.3.1.3 Fixed Interval or Time based schedule i.e. schedule on the basis of Months or year:

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.

8.3.2 Categorization of Vehicle for Maintenance purpose:

It is very difficult to bring the various types of vehicles and equipment operated at an airport in a single maintenance programme. However, the following table will give some general guidelines on the issue:

Equipment maintenance intervals

SN	Equipment	Maintenance intervals		Remarks
		km driven	Hrs. Operated	
1	RFF vehicles, Ambulances	3,000 to 5,000 kms.	100 to 200 Hrs.	Whichever comes first.
2	Standard cars, station wagons, microbuses, buses	5,000 kms.	---	
3	Special passenger buses	---	100 to 200 Hrs.	At least twice a year.
4	Standard trucks, aircraft towers, runway sweepers, mowers.	---	100 to 200 Hrs.	At least twice a year.

5	Self-driven aircraft handling equipment (lifters, electric power trucks, water trucks, etc.)	---	100 to 200 Hrs.	
6	Other aircraft handling equipment (dollies, stairs, etc.)			Once or twice a year.

8.3.3 Advantages of Fixed Interval or Time based schedules:

Fixed time intervals offer the advantage of well-balanced workshop utilization. Equipment with a low number of operating hours per year should fall in this category. But in such cases the equipment shall be inspected regularly. Otherwise, maintenance to protect from true wear cannot be met, since the individual use of equipment is not considered.

8.3.4 Defining the maintenance intervals:

The user (or proprietor) of the vehicles will define the maintenance intervals in accordance with experience, manufacturer's recommendation and work-shop capacity. No standards, but only guidelines, can be given.

8.3.5 Determining factors of maintenance schedules:

The maintenance programme for each type of vehicle or equipment will depend on the following factors:

a. Function of the vehicle or equipment, b. Wear and tear characteristics, and
c. Manufacturer's recommendation. Inspection must be carried out by specialists.

8.3.6 Servicing of radio-telecommunication equipment:

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 all times.

8.3.7 Inspections and maintenance:

Inspections and checks play a very important role in the process of maintenance of equipment and vehicles, and there by in keeping them serviceable up-to the mark. 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 shall be taken out of service and repair shall be carried out as soon as practicable.

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END.