**CHAPTER 3 -- ELECTRICITY SUPPLIES**

3.1 **GENERAL**

3.1.1 The supply of power for aerodromes should be determined before the design of the aerodrome lighting installations are initiated. The electrical power for these installations is usually only a small part of the total electrical power used by the aerodrome. Whether the visual aids being installed are for a new aerodrome or for modernization and expansion of an existing aerodrome, the sources of power should be analyzed for availability, capacity, reliability, practicality for the proposed installation, and for future expansion. This analysis should include consideration of requirements of Annex 14, Table 8-1 for use in cases of failure or malfunction of the normal power supply.

3.2 **SOURCES OF POWER TO THE AERODROME**

3.2.1 **Commercial power source.** Most aerodromes obtain power through means of feeders from a widely interconnected electricity network outside the aerodrome. For major airports it is desirable to have at least two independent incoming power sources coming from widely separated sections of the electricity network beyond the aerodrome with each supplying separate substations on aerodrome property.

This power is usually supplied at high voltage (over 5000 volts) to the aerodrome main power substation. The voltage is reduced at the aerodrome substation to an intermediate voltage (2000 to 5500 volts) for distribution within the aerodrome. A further step-down of voltage may be necessary to match the input voltage of the equipment.

Within the aerodrome, reliability in the supply of power to the individual stations can be improved by using a closed ring high voltage input circuit with balanced voltage protection on the distribution transformers or by using a double loop system from independent primary sources operating as open rings feeding two transformers at each station. With use of centralized monitoring of fault currents and thereby operation of transfer switches within the loops, the impact of power failures can be minimized. Simpler arrangements providing lesser reliability may be used at smaller airports.

3.2.2 **Independent local power source.**

3.2.2.1 In addition to a commercial source, some aerodromes for economic reason may have their own plant facilities for supply of power. The local power source may be in the form of a diesel-electric generator unit, gas engine, turbine generator or even solar power plants such as that shown below at Saarbrucken Airport in Germany. The design/orientation of solar power plants should avoid possible glare to pilots using the aerodrome.
3.3 POWER SUPPLY TO AERODROME VISUAL AIDS

3.3.1 Table 3-1 [reproduced from Table 8-1 of ICAO Annex 14] stipulates the provision of a standby power supply for certain aerodrome lighting facilities [i.e. non-precision approach, precision approach category I, precision approach category II/III and runways meant for take-off in RVR conditions less than a value of 800m.]. The intent is to design the lighting system such that, upon occurrence of failure or malfunction of the "normal" supply, automatic transfer takes place to the "standby" supply within a specified period of time.

3.3.2 It is of importance to note that the designations of "normal" and "standby" supply are labels that are applied to power sources as appropriate for the mode of operation and transfer time. Generally, an aerodrome would have a commercial power source and a diesel electric generator unit or Interruptible Power Unit (IPU) for the lighting systems. As shown in Figure 3-2, in the case of non-precision approach and precision approach category 1, the IPU would be labelled as "standby" and the commercial power source as "normal", for reason that the IPU can be started and stabilized within the maximum time period of 15 seconds. In the case of precision approach category 2/3 and for take-off in RVR less than 800m, the stipulated transfer time of 1 second requires that the IPU first be brought into operation ... thus labelled as "normal" ... and the commercial power source labelled as "standby".

3.3.3 A second commercial power source may be designated for service as the standby source. However, such design approach necessitates a high level of service. The integrity of operations provided by independent commercial power sources depends on the separation and independence of these sources. If both come from interconnected distribution networks, a failure in the network may cause both sources to fail. In addition, the alternate sources may not be in a reserve status only and may be supplying electrical power to other facilities on the aerodrome. The latter should have adequate capacity to provide the power for essential aerodrome lighting aids when required. As well, attention must be paid to coordination of protective devices such that the failure of a non-essential load does not lead to complete loss of the supply including that to the visual aids.
3.3.4 Although the use of a second commercial or local independent power source is feasible, it is preferable that the aerodrome visual aids be provided with its own local power source in the form of an engine-generator sets with capacities ranging from 50 to more than 1000 KVA. This local power source should be capable of supplying power for a time period that exceeds the maximum time needed to restore power from the primary source. Engine-generator sets are often expected to operate for 24 to 72 hours without refuelling.

3.4 UNINTERRUPTIBLE POWER SUPPLY (UPS)

An alternate method utilizes a Uninterruptible Power System (UPS). As shown in Figure 3-3a, for initial operation the commercial source is the NORMAL supply to the CCRs. With failure of the commercial source a two step process then takes place. In Step 1, the UPS provides power to the CCRs. This step may last for 15 to 30 minutes or more depending upon the size of the batteries. Prior to exhaustion of the batteries, the IPU is started so that it is available to take over the load in Step 2. In as much as the CCRs are not exposed to an interruption for startup of the STANDBY supply, the process can similarly be applied for Category II/III operations. The benefit for the airport is twofold. Since the IPU is the STANDBY supply for Category II/III, its hours of operation are substantially reduced leading to economies for fuel consumption and maintenance. Reduction occurs as well for Category 1 operation since the UPS can provide power for failures of the commercial source which are less than 30 minutes. The associated benefit is environmental in that a reduction in hours of operation of the IPU also reduces emissions and thus the carbon footprint of the airport.
A further alternative is to separate out particular lighting facilities such as that for runway edge and runway centreline/touchdown zone lighting as shown in Figure 3-3b such that the former is supplied prior to the UPS. In this fashion, the IPU serves as STANDBY under Category 2 operations yet the facilities are provided with the necessary minimum interruption time according to Annex 14 Table 8-1. When transfer occurs the UPS provides power to the runway centreline/touchdown zone lighting to meet the 1 second requirement [actually is 0 seconds] whilst the runway edge lighting waits through the 15 second startup for the IPU.

A rotary UPS, composed of a motor-generator, inertia storage device and diesel combines the functionality of the static UPS with a capability to continue operations for several hours depending upon the availability of fuel for the diesel.
### Table 3-1 (Table 8-1 of Annex 14) Power supply requirements for Visual aids

<table>
<thead>
<tr>
<th>Runway</th>
<th>Lighting aids requiring power</th>
<th>Maximum switch-over time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-precision approach</td>
<td>Approach lighting system&lt;br&gt;Visual approach slope indicators (a) (d)&lt;br&gt;Runway edged&lt;br&gt;Runway threshold (d)&lt;br&gt;Runway end&lt;br&gt;Obstacle (a)</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Precision approach category I</td>
<td>Approach lighting system&lt;br&gt;Runway edged&lt;br&gt;Visual approach slope indicators (a) (d)&lt;br&gt;Runway threshold (d)&lt;br&gt;Runway end&lt;br&gt;Essential taxiway (a)&lt;br&gt;Obstacle (a)</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Precision approach category II/III</td>
<td>Inner 300m of the approach lighting system&lt;br&gt;Other parts of the approach lighting system&lt;br&gt;Obstacle (a)&lt;br&gt;Runway edge&lt;br&gt;Runway threshold&lt;br&gt;Runway end&lt;br&gt;Runway centreline&lt;br&gt;Runway touchdown zone&lt;br&gt;All stop bars&lt;br&gt;Essential taxiway</td>
<td>1 second</td>
</tr>
<tr>
<td>Runway meant for take-off in runway visual range conditions less than a value of 800 m</td>
<td>Runway edge&lt;br&gt;Runway end&lt;br&gt;Runway centre line&lt;br&gt;All stop bars&lt;br&gt;Essential taxiway (a)&lt;br&gt;Obstacle (a)</td>
<td>15 seconds (c)</td>
</tr>
</tbody>
</table>

(a) Supplied with secondary power when their operation is essential to the safety of flight operation.
(b) See Chapter 5, 5.3.2 regarding the use of emergency lighting.
(c) One second where no runway centre line lights are provided.
(d) One second where approaches are over hazardous or precipitous terrain.

### 3.5 TRANSFER (SWITCHOVER) TIME REQUIREMENTS

3.5.1 When the normal power source for critical visual aids fails, the load must be transferred to the standby power source. In the case of a local power source such as a diesel-electric generator unit, this source must be started and speed and voltage stabilized before the load is transferred.

3.5.2 The "maximum Switch-over time", as shown in Figure 3-4 is defined as the duration for the measured intensity of a light to fall from 50 per cent of the original value and recover to 50 per cent during a power supply changeover, when the light is being operated at intensities of 25 percent or above.
3.6 EQUIPMENT

3.6.1 References. The following is a selection of IEC standards documents applicable to electrical installations.

IEC 60228: Conductors of insulated cables
IEC 60364: Electrical installations of buildings
IEC 61000: Electromagnetic compatibility (EMC)
IEC 61024-1: Protection of structures against lightning—part 1: Protection of structures against fire, explosion and life hazards
IEC 61140: Protection against electric shock: Common aspects for installations and equipment
IEC 61200-52: Electrical installation guide—part 52: Selection and erection of electrical equipment—Wiring systems
IEC 61821: Electrical installation and beaconing of aerodromes: Maintenance of aeronautical ground lighting constant current series circuits
IEC 61822: Electrical installation and beaconing of aerodromes: Constant current regulator
IEC 61823: Electrical installation and beaconing of aerodromes: Aeronautical ground lighting series transformer
IEC/TS 61827: Electrical installation and beaconing of aerodromes: Characteristics of inset and elevated luminaires used on aerodromes
IEC 61820: Electrical installations for the lighting and beaconing of aerodromes: Constant current series circuits for aeronautical ground lighting: System design and installation requirements
IEC/TS 62143: Electrical installations for lighting and beaconing of aerodromes—Aeronautical ground lighting systems—Guidelines for the development of a safety lifecycle methodology

3.6.1 Components

3.6.1.1 The components of the electrical power system should be of such quality that they will provide the reliability, availability, and voltages and frequencies needed by the facility. The major items of equipment commonly used for aerodrome lighting are engine-generator sets, power-transfer switching devices, to furnish power for starting the engine generators, and vaults or shelters for this equipment.
3.6.2 Engine-generator sets

3.6.2.1 The basic secondary power engine-generator set consists of a prime mover, a generator or alternator, a starting device, starting controls, and a fuel tank or supply. Engine-generator sets for secondary power units are usually in 100 to 500 kilovolt-amperes capacities but may range from 50 to 1000 kilovolt-amperes in capacity.

(a) Prime movers. The prime movers for most secondary power units are gasoline, diesel, or gas engines or turbines, the choice being based on cost and availability of fuels. These prime movers are usually available in standardized sizes with adequate power to handle the kilovolt-ampere rating of the generator. The prime movers for most major aerodromes are rapid-start types which can start automatically, stabilize the speed, and be connected to the load within 10 seconds.

(b) Generators. The generator, usually an alternator, is mechanically coupled to the prime mover and provides secondary electrical power at the frequency, voltage, and power rating of the unit. These generators may be either single phase or three phase. They should have high efficiency in converting mechanical energy to electrical energy.

(c) Starting devices. Most secondary power engine-generator sets use battery packs to store energy for starting. Because of infrequent use, short operating periods, high starting current demands, and cost, lead-acid type batteries are used most frequently for starting these units. The battery pack (often a set of batteries connected in series and/or parallel) must be capable of providing the voltage and current needed to start the engine within the required time limits and under the most severe conditions (usually a low temperature of -7 degrees Celsius) at which the secondary power unit is expected to operate. A battery charger with over-current and overcharge control is permanently connected to the electrical power to maintain the stored energy in the batteries. The battery pack should be...
well ventilated to prevent accumulation of hydrogen gas and should be protected from arcs, sparks, or flames which could cause an explosion of any accumulated gas. Nickel-cadmium batteries may be used where special conditions warrant their high initial cost. Flywheels, pneumatic pressure vessels, other-than-battery stored-energy devices are used infrequently for engine starting because of unreliability or cost.

(d) Starting controls. The controls for the engine-generator set are usually automatic start with the sensor for primary power failure as part of the transfer switching device. Manual or remote controls are sometimes used for facilities with low critical requirements. Once it is started, speed and power are automatically regulated by the engine and the electrical load is connected by the transfer switch. The engine generator should operate automatically without adjustment or other attention. Transfer of power back to the primary source and stopping the engine may be automatic or by remote control.

(e) Fuel supply. Liquid fuel for secondary power is usually stored in tanks near the engine generator location. The capacity of the fuel tanks should be adequate for the maximum operating time expected of the engine-generator. Some authorities require a minimum of 72 hours supply. Others design for a lesser time period, but the time period usually should be at least twice the maximum duration expected of conditions that could require the use of secondary power. Fuel tanks and connections should meet all safety requirements and should provide convenient access for refuelling. These tanks should also provide arrangements for testing for contamination of the fuel, especially the accumulation of water in the tank.

3.6.3 Power transfer switching

3.6.3.1 A suitable transfer device is needed for transferring power from the primary source to the secondary source. For manual starting and control this may be a simple switch or relay that disconnects the load from one power source and connects it to the other. Additional controls are needed for automatic transfer. These are usually combined into a single control unit or cubicle. Such a unit should be capable of sensing the failure of primary power, initiating the starting of the prime mover of the secondary generator set, determining that the voltage and frequency of the generator have stabilized adequately, and connecting the load to the generator. This unit may also disconnect nonessential loads and facilities which are not to be energized by the secondary source and transfer these loads back to the primary source after that power has been restored. The switches or relays for disconnecting and connecting the load should have the capacity to handle the rated load of the generator. The functioning of these switches or relays is similar for either the 15-second, or 1-second transfer times, although more rapid-acting relays may be needed for the shortest transfer time. For a 15-second transfer, the sensors must respond in less than 3 seconds each because the quick starting engines need 10 seconds to start and to stabilize.
3.7 VAULTS AND SHELTERS FOR ELECTRICAL EQUIPMENT

3.7.1 Shelters

3.7.1.1 Most electrical equipment for airport lighting and other facilities is located in vaults or special shelters for protection from the weather and for better security. Substations for high voltage are usually outdoors, and medium voltage distribution transformers are often placed on fenced transformer pads. Most electrical vaults are above ground and made of fireproof materials. Reinforced concrete for the floors and concrete, concrete or cinder block, and/or brick for the walls are materials commonly used in these vaults. The use of such materials reduces the hazard of electric shock, shorting of electrical circuits, and fire hazards. Prefabricated metal structures are occasionally used as shelters for transformers and engine-generator sets. These vaults are used to house the power distribution and control equipment, secondary power equipment, and the various devices used to provide power and control for the airport lighting systems. The vaults should be of adequate size to contain the necessary equipment without crowding and may be divided into rooms for better segregation of equipment and activities.
3.7.2 Location

3.7.2.1 Electrical vaults should not be located where they would infringe on obstacle limitation surfaces. The distances from the control tower to the vaults should be short enough to avoid excessive voltage drop in the control cables. The permissible length of these cables varies with the size of the cable, the control voltage, and the types of control relays used, but some of the longer control systems limit the length of control cables to about 2250m. Vehicular access to the vaults in all types of weather conditions is necessary and minimum conflict with aircraft traffic is desirable. The location should be convenient for connecting to the appropriate lighting circuits and facilities to keep feeder cable lengths as short as is practical. The vaults should be isolated from other buildings and facilities to prevent the spread of fires or explosions, except the shelters for secondary engine-generator sets may be near the electrical vault to reduce cable length and size and to simplify the power transfer system. Aerodromes with approach lighting systems may need separate approach lighting vaults for each approach lighting system. For major aerodromes, some authorities use a vault near each end of the runway or approach lighting system to more easily arrange for interleaving of the lighting circuits and to improve integrity of the systems.

3.7.3 Special provisions

3.7.3.1 As special purpose buildings, electrical vaults may require special features to provide safety and reliable performance of the equipment. Some of these features are as follows:

   a) Ventilation. Provide adequate ventilation to prevent transformer temperatures exceeding the values prescribed by the equipment manufacturers. Most of the electrical heat losses must be removed by ventilation; only a minor part can be dissipated by the vault walls. Some electrical codes recommend 20 cm² of clear grating area per kilovolt-amperes of transformer capacity. In localities with above-average temperatures, such as tropical or subtropical areas, the grating area should be increased or supplemented by forced ventilation.
b) Access. Adequate access should be provided for repairs, maintenance, installation, and removal of equipment.

c) Drainage. All vaults should be provided with drainage. When normal drainage is not possible, provide a sump pit to permit the use of a portable pump.

d) Security. Each electrical vault should be equipped to deter inadvertent or premeditated access by unauthorized persons. This security is necessary to prevent interference with equipment operation and to protect those persons from possible electric shock. Some methods used are barred and screened windows, heavy-duty metal doors with padlocks, and security fencing.

e) Vault lighting. Electrical vaults should be well illuminated for use during day or night. This lighting is usually provided by interior lights of a size, type, and location to provide good visibility in all areas. Poor visibility can increase the potential for accidents resulting in electrical shock or improper control and adjustments. The vault should be provided with emergency lighting that will be operational upon failure of the main power supply.

f) Local communications. Most electrical vaults should be provided with convenient and reliable communications to the control tower, other vaults, and perhaps other facilities or offices. Special telephone or intercommunication systems may avoid outside interference with these circuits, but other dependable arrangements can be used.

g) Electrical conduits. Electrical vaults should be provided with a sufficient number of conduits and cable entrance accesses to avoid later modification of the structure to permit the installation of additional input or output circuits. These cables entrances are usually through underground conduits which may be connected to existing cable ducts, direct-burial cables, or unused conduits available for future expansion. Unused conduits should be plugged, and conduits with cables should be sealed.

h) Installations of equipment. Arrange the equipment, especially the larger items such as regulators, distribution transformers, control panels, and circuit selector or control devices, to provide a simple, uncluttered plan. This arrangement should consider safety, especially protection from high voltage electrical connections, as well as access to the equipment and controls. The electrical circuits should also be arranged in a simple pattern wherever possible. Follow the applicable electric safety codes for installing all electrical circuits and controls.

i) Where the engine generator and switchgear are located in a separate enclosure from the constant current regulators, interconnection should be made by means of placing the feeder in concrete encased duct or steel conduit, without splices or intermediate manholes. If their location is relatively remote, connection should be made by means of a dual feeders.
3.7.4 Capacitors

3.7.4.1 Types of capacitors. Use shunt capacitors to improve the power factor of the load carried by the circuit. In applying capacitors, consider the following:

a) Fixed capacitance. Fixed capacitance is the amount of capacitance that can be applied continuously without excessive voltage rise at reduced load.

b) Switched capacitance. Switched capacitance is an additional amount of capacitance that can be applied, if provision is made to switch off this additional amount at reduced demand.
c) Capacitor switching. Select a type of capacitor switching that is suitable for the condition at hand. Possible choices include remote control of the capacitor switching device, time-lock control, power-factor relay control or voltage-sensitive relay control.

3.7.4.2 Location of capacitors. Install capacitors in banks, at ground level, or in a substation as nearly as possible to the centroid of the area where correction is required.

3.7.4.3 Switches. Use switches to localize defective portions of aerial and underground circuits and to accomplish dead-circuit work. Select from one of the following principal types:

(a) Nonload-break switches. Use nonload-break switches only for the interruption of circuits that carry no appreciable load. Select the type applicable, depending on circuit importance, load, voltage, and fault circuit duty. The types available are porcelain disconnect fuse cutouts, plain or fused single pole air disconnect switches, and disconnect fuse cutouts of various types. Disconnecting and horn-gap switches may also be used as nonload-break switches. All such nonload-break switches should have a closure rating that is greater than the short circuit current available on the circuit.

(b) Load-break switches. Load-break switches are provided with an interrupting device capable of disconnecting circuits under load. Fuse cutouts, which are designed to be load-break and load interrupter switches, are available. Vacuum switches also provide load-break capability.

3.7.4.4 Counters. As a means of maintenance, event counters and elapsed time counters may be installed in electrical equipment.