

Referenced to Nigeria Regulations



Advisory Circular

NCAA-AC-ARD002-A

NIGERIA CIVIL AVIATION AUTHORITY (NCAA)

ISSUE NO 1

DATE: 17TH JULY, 2023

GUIDANCE TO THE AERODROME OPERATOR ON ELECTRICAL SYSTEMS

Made this ^{17th} day of ^{July} 2023

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1.0 GENERAL

Nigeria Civil Aviation Authority Advisory Circulars from Aerodrome Standards Department contain information about standards, practices and procedures that the Authority has found to be an Acceptable Means of Compliance (AMC) with the associated Regulations.

An AMC is not intended to be the only means of compliance with a regulation, and consideration will be given to other methods of compliance that may be presented to the Authority.

Information considered directive in nature is described in this AC in terms such as “shall” and “mu-st”, indicating the actions are mandatory. Guidance information is described in terms such as “should” and “may” indicating the actions are desirable or permissive, but not mandatory.

2.0 PURPOSE

This advisory circular (AC) provides guidance to aerodrome operators on Aerodrome electrical systems. It also provides basic guidance for and lines of responsibility for the day-to-day provision of secondary power at an Aerodrome.

3.0 APPLICABILITY

This AC applies to operators on Aerodrome Certification, Safety Assessments and Aerodrome Compatibility

4.0 REFERENCE

- (a) Nig.CARs Part 12 Vol I, 12.2.1 – Aerodrome Design and Operations Standards
- (b) ICAO Doc 9157 – Part 5 (Electrical Systems)

5.0 STATUS OF THIS AC

The AC is the first to be issued on this subject.



AMENDMENT PROCEDURES

The Director, Aerodrome and Airspace Standards is responsible for the development, issuance and control of amendments to this document as well as ensuring that the AC is updated in the technical library for staff and the website ncaa.gov.ng for public use.

Each page will show the document number, issue/amendment number, issue date and page number at the base of the page.

All amendments must be recorded in the Record of Amendments.

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1. ELECTRICITY SUPPLIES

1.1 Primary Power

- (a) The primary power supply to the aerodrome may be obtained from a power source external or internal to the aerodrome operator.
- (b) An external power source may be an interconnected electricity network outside the aerodrome.
- (c) The local power source may consist of power plant facilities within the aerodrome in the form a diesel-electric generator unit, gas engine, turbine generator or solar power plant.
- (d) For major airports, it is desirable to have at least two independent incoming power sources with each supplying separate substations on the aerodrome property. The selection of the incoming power sources can be based on the least probability of simultaneous failure of both sources.
- (e) Power to the aerodrome main power substation is generally supplied at a high voltage (over 5000 volts). 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 required input voltage of visual aids equipment.
- (f) For the purposes of determining the capacity of power supply required, the aerodrome operator needs to determine the total power demand for the functioning of all the aerodrome facilities, taking into account the existing facilities, their tolerances, seasonal variations of the demand, and anticipated expansion of the aerodrome. This can be achieved through establishing for each existing facility, equipment and installation, the consumption requirements based on the information provided by the manufacturer, supplier, construction companies, and aerodrome users. The sum of the unit power consumption requirements of the existing and planned aerodrome facilities can be used to estimate the minimum electricity demand of the aerodrome.

1.2 Secondary Power

- (a) **Table 1-1** - lists the requirements for the provision of a secondary power supply to certain aerodrome lighting facilities.
- (b) The design objective for the aerodrome electrical system is such that, upon occurrence of failure or malfunction of the primary supply, automatic transfer takes place to the secondary supply within a specified period of time - the maximum switch over time. When the primary power source for the designated facilities fails, the load must be transferred to the secondary power source.



- (c) The "maximum switch over time" 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 per cent or above. As such, the switch over time is really an interruption time of the light output rather than of the electricity.
- (d) In addition to the aerodrome lighting facilities listed in table 1-1, the following facilities shall be provided with a secondary power supply capable of supplying power when there is a failure of the primary power supply:
- (i) the signalling lamp and the minimum lighting necessary to enable air traffic services personnel to carry out their duties;
 - (ii) all obstacle lights which, in the opinion of the Authority, are essential to ensure the safe operation of aircraft;
 - (iii) approach, runway and taxiway lighting as specified in Nig.CARs Part 12 Vol I, 12.2.5.3
 - (iv) meteorological equipment;
 - (v) essential security lighting, if provided;
 - (vi) essential equipment and facilities for the aerodrome responding emergency agencies;
 - (vii) floodlighting on the designated isolated aircraft parking position; and
 - (viii) illumination of apron areas over which passengers may walk.
- (e) The requirements for a secondary power supply can be met by either of the following:
- (i) independent public power supplying the aerodrome service from a substation other than the normal substation through a transmission line following a route different from the normal power supply route and such that the possibility of a simultaneous failure of the normal and independent public power supplies is extremely remote; or
 - (ii) standby power units, which are engine generators, batteries, etc., from which electric power can be obtained.
- (f) The standby power unit may consist of an engine generator set or interruptible power unit (IPU). In the case of non-precision approach and precision approach Category I, the IPU is on "standby" and can be started and stabilized within the maximum time period of 15 seconds.
- (g) In the case of precision approach Category II/III and for take-off in VR less than 800m, the stipulated transfer time of 1 second requires the use of an

uninterruptible power supply (UPS) (sometimes called uninterruptible power source or uninterruptible power system). Upon failure of the primary source a two-step process then takes place. In Step 1, the UPS provides power to the lighting facilities. This step may last for 15 to 30 minutes or more depending upon the size of the batteries. In Step 2, prior to exhaustion of the batteries, the IPU shall be started so that it is available to take over the load.

- (h) A further optimized method of meeting required interruption time is to separate particular lighting facilities such as that for runway edge and runway centreline/touchdown zone lighting, so that the latter is supplied by the UPS. In this fashion, the IPU serves as standby for all facilities under Category I operations according to Table 1-1. When transfer occurs, the UPS provides power to the runway centreline/touchdown zone lighting to meet the second requirement whilst the runway edge lighting waits through the 15-second start-up for the IPU.

Table 1-1: Secondary Power Supply Requirement

Runway	Lighting aids requiring power	Maximum switchover time
Non- instrument	visual approach slope indicators ^a	15 seconds
	Runway edge ^b	15 seconds
	Runway threshold ^b	15 seconds
	Runway end	15 seconds
Non-Precision approach	Approach lighting system	15 seconds
	visual approach slope indicators ^{a,d}	15 seconds
	Runway edge ^d	15 seconds
	Runway threshold ^d	15 seconds
Precision approach category I	Approach lighting system	15 seconds
	Runway edge ^d	15 seconds
	visual approach slope indicators ^{a,d}	15 seconds
	Runway threshold ^d	15 seconds



Precision approach category II/III	Inner 300m of the Approach lighting system	1 seconds
	Other parts of the approach lighting system	15 seconds
	Obstacle ^a	15 seconds
	Runway edge	15 seconds
	Runway threshold	1 second
	Runway end	1 second
	Runway centre line	1 second
	Runway touchdown zone	1 second
	All stop bars	1 second
	Essential taxiway	15 seconds
Runway meant for Takeoff in runway visual range conditions less than a value of 800m.	Runway edge	15 seconds ^c
	Runway end	1 second
	Runway centre line	1 second
	All stop bars	1 second
	Essential taxiway ^a	15 seconds
	Obstacle ^a	15 seconds

- a. Supplied with secondary power when their operation is essential to the safety of flight operation.
- b. See, 12.2.5.5(c)(2) of this Part 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.

Note 1 - The time interval between failure of the primary source of power and the complete restoration of the services should be as short as practicable, except that for visual aids associated with non-precision, precision approach or take-off runways the requirements of Table 1-1 for maximum switch-over times apply.

Note 2 - At an aerodrome where the primary runway is a non-instrument runway, a secondary power supply capable of meeting the requirements of Nig.CARs Part 12 Vol I, 12.2.8 should be provided, except that a secondary power supply for visual aids need not be provided when an emergency lighting system is provided and capable of being deployed in 15 minutes.

- (i) The engine-generator set contemplated in section 1.2(e)(ii) consists of a prime mover, a generator, a starting device, starting controls, and a fuel tank. The



capacity is determined by the power demand for secondary power, i.e. the facilities to be connected to the secondary power supply.

- (i) **Prime movers.** The prime movers for most secondary power units are gasoline, diesel, or gas engines or gas turbines. These prime movers are usually available in standardized sizes with adequate power to handle the kilovolt-ampere rating of the generator. The prime movers should be selected from rapid-start types which can start automatically, stabilize their speed, and be connected to the load within 15 seconds.
- (ii) **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. They may be either single-phase or three-phase generators. They should be selected for the high efficiency in converting mechanical energy to electrical energy.
- (iii) **Starting devices.** Most secondary power engine-generator sets use battery packs to store energy for starting. The battery pack (often a set of batteries connected in series and/or parallel) must be selected for its capability of providing the voltage and current needed to start the engine within the required time limits and under the most severe weather conditions 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.
- (iv) **Starting controls.** The controls for the engine-generator set are usually an automatic start with a sensor for primary power failure as part of the transfer switching device. Manual or remote controls may be 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.
- (v) **Fuel supply.** Liquid fuel for the IPU is usually stored in tanks near the engine generator location. The capacity of the fuel tanks must be adequate for the maximum operating time expected of the engine generator, and at least twice the maximum duration expected of conditions that could require the use of secondary power. The aerodrome operator shall keep records of interruption of the primary power and duration of such interruptions. Fuel tanks and connections shall meet all safety requirements and should provide convenient access for refueling. These tanks are also to be



designed to provide arrangements for testing for contamination of the fuel, especially the accumulation of water in the tank.

- (j) A suitable transfer device is needed for transferring power from the primary supply to the secondary supply. 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 must be capable of sensing the failure of normal supply, initiating the starting of the standby unit, determining that the voltage and frequency of the generator have stabilized adequately, and connecting the load to the generator. This unit may also disconnect non-essential loads and facilities which are not to be energized by the standby supply and transfer these loads back to the normal supply after it has been restored. The switches or relays for disconnecting and connecting the load must 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 1second 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 at least 10 seconds to start and to stabilize.

2. DESIGN OF AERODROME ELECTRICAL SYSTEMS

2.1 Interleaving of Aerodrome Lighting Circuits

- (a) For a runway meant for use in runway visual range conditions less than a value of 550m, the electrical systems for the power supply, lighting and control of the lighting systems shall be designed so that an equipment failure will not leave the pilot with inadequate visual guidance or misleading information. To this end, every approach and runway lighting system should be interleaved with at least two circuits. Examples of circuit interleaving to improve integrity are shown in **Figure 2-1 to Figure 2-5**. Each circuit in an interleaved system should extend throughout the whole of the service (e.g. runway length) and be so arranged that a balanced symmetrical lighting pattern remains in the event of failure of one or more of the circuits.
- (b) The principle of interleaving needs to be carried to the electrical vault and beyond. As shown in **Figure 2-1**, the circuits and associated regulators are fed from separate buses such that each circuit is supplied from a separate Constant Current Regulator (CCR) and arrangement is made such that a spare CCR is available to be placed in operation within a minimum amount of time. The buses are provided with automatic tiebreakers for use in case of failure.
- (c) As a further means of assuring availability in case of failure, arrangement may be made to enable switching to a spare regulator, as shown in **Figure 2-2**. This method may be used where the regulator consists of the regulating component and input/output transformers. In the case of regulators that consist of only the regulating component, a rack mounted or plug-in design is used and availability is achieved by use of a spare regulator that can be readily installed in place of the failed regulator.
- (d) The interleaving of approach lighting Type A (distance coded centreline) and Type B (barrette centreline) are illustrated in **Figure 2-3**. Both the Category I system and supplemental lighting for Category II/III operations are shown.
- (e) Threshold lights are composed of those associated with the runway edge system and those associated with the approach lighting system. The threshold lights for the runway are runway end/threshold lights with red and green signals (facing opposite) at each light station. In **Figure 2-3**, six runway threshold lights are shown for a Category I installation. A Category II/III installation would have additional runway end/threshold lights. The runway end/threshold lights are usually interleaved as part of the runway edge lighting system.

Interleaving for the approach lighting system involves the unidirectional green threshold lights and the wing bar lights.

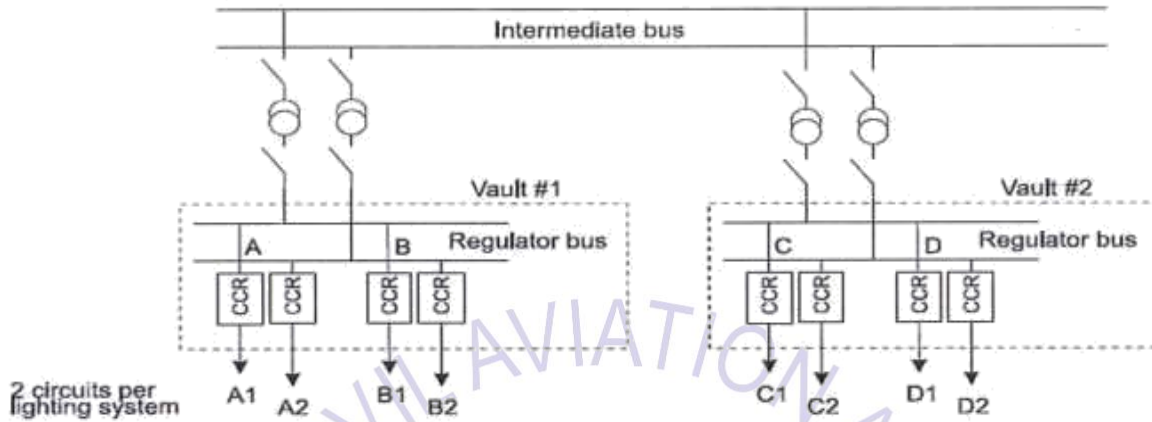


Figure 2-1: provision of interleaved circuits

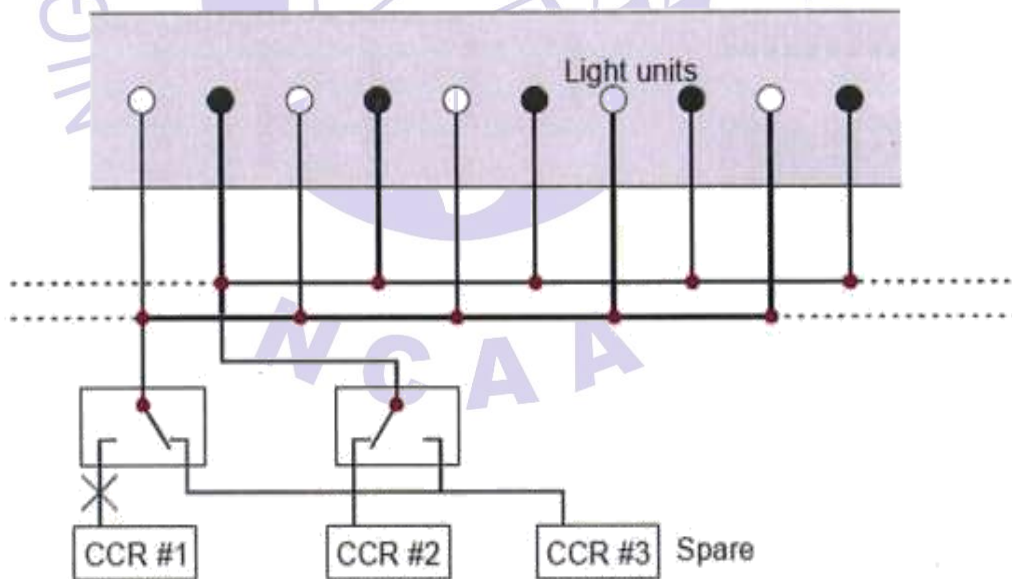


Figure 2-2: use of a separate regulator



- (f) Runway centreline lights shall show variable white to a distance of 900 m from the threshold, then alternating variable white and red from 900 m (or from the mid-point of the runway) to 300 m from the runway end after which only red is shown to the pilot. Figure 2-5 (b) illustrates the interleaving for the first white only portion of the system. Similar interleaving would be used for the final all red portion.
- (g) Figure 2-4 illustrates various means to provide interleaving for the coded white/red portion of the system and selection is that prescribed by the local authority. Where it is necessary to preserve the colour coding, Figure 3-4(a) should be used. However, this interleaving would increase the spacing in failed segments to three times the normal value. Figure 2-4 (d) illustrates an interleaving arrangement where lights are installed with 7.5 m spacing and couplets of the same colour are installed. Figure 2-4 (b) does not preserve the coding (with circuit failure the lights are either all red or all white), but does maintain an acceptable spacing for provision of a pattern of lights for centreline guidance (the spacing is doubled with circuit failure).
- (h) Figure 2-5 also illustrates the interleaving of runway touchdown zone lights. The interleaving of Figure 2-5 (d) so preferred because to maintains the longitudinal spacing between barrettes upon loss of one circuit.
- (i) Taxiway centreline lighting circuits may be interleaved on those parts of the taxiway system that are considered as essential in category II/III conditions but a single circuit may be used for other taxiways. Where the taxiway centreline lighting is colour coded green/yellow to indicate the distance of the aircraft exit from a runway in relation to the ILS critical area, the system may be interleaved by one of the methods illustrated in Figure 2-4. As in the case of runway centreline lighting, Figure 2-4 (a) preserves colour coding but leaves failed segments that are three times the normal light spacing. Figure 2-4 (b) causes an increased spacing which is twice the norm, but also does not preserve the coding such that the exiting pilot would see either a line of green or yellow lights. The method of Figure 2-4 (c) preserves minimal spacing but is more costly. The method of Figure 2-4 (d) is an alternative which preserves the colour coding and leaves a normal spacing if the lights are installed at half the normal spacing (e.g. at 7.5 m instead of 15 m).
- (j) Stop bars must be controlled independently of each other and of the taxiway centreline lights. The electrical circuits need to be interleaved so that all of the lights of a stop bar will not fail at the same time.
- (k) Stop bars are normally associated with taxiway centreline lead-on lighting. The green lead-on lighting provides a confirmation of voice instruction for the aircraft to proceed once the stop bar is turned off. When the stop bar is illuminated, the taxiway centreline lights installed beyond the stop bar are extinguished for a distance of at least 90 and vice versa. Control and monitoring of the lead-on



lights can be accomplished through means of addressable switches whilst the power supply and possible interleaving is that of the taxiway centreline lighting. Should the supply to the lead-on lights be other than a dedicated circuit, it is necessary to ensure that the circuits to which these lights are connected will be active when the lead-on lighting is required.

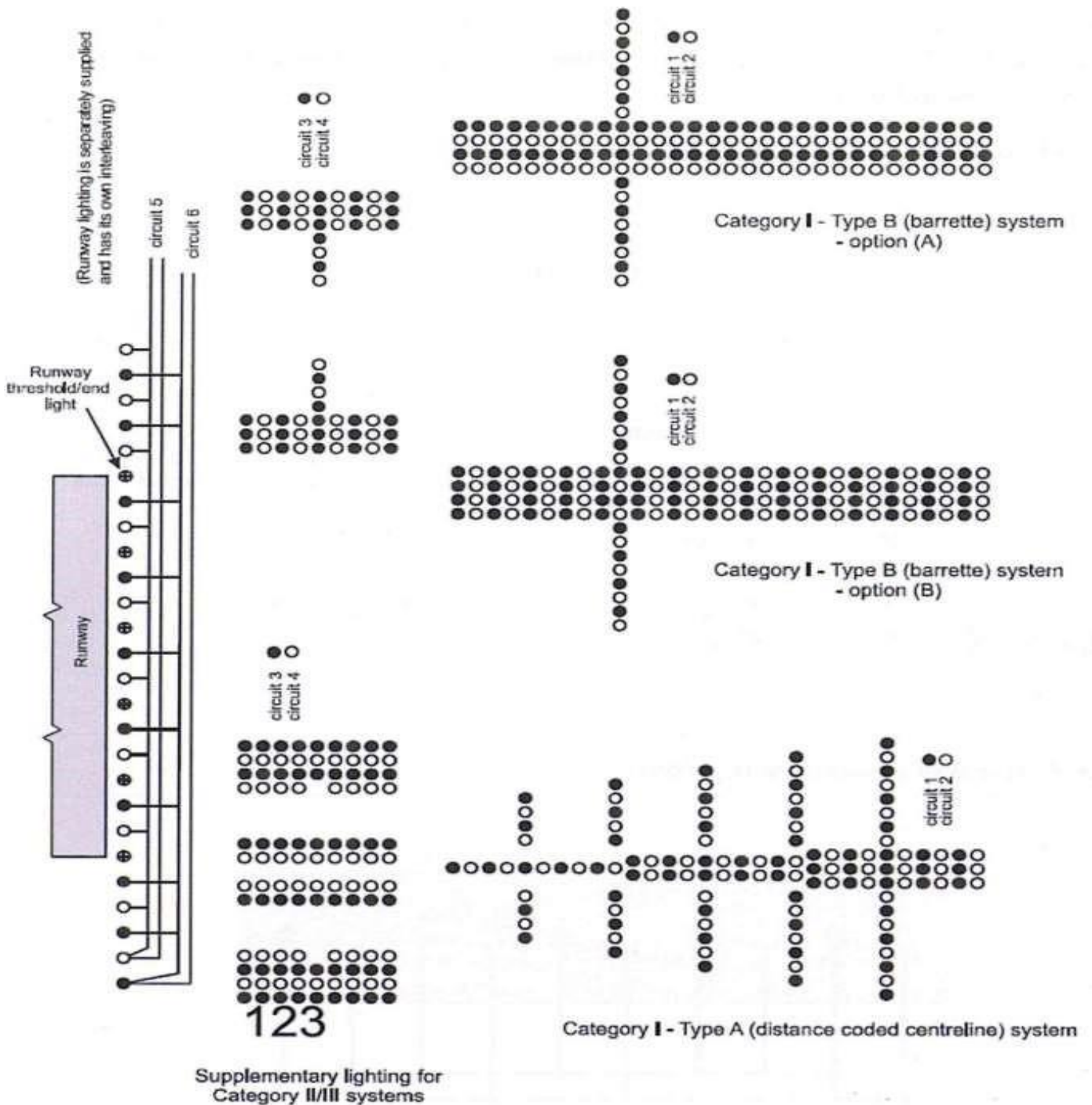
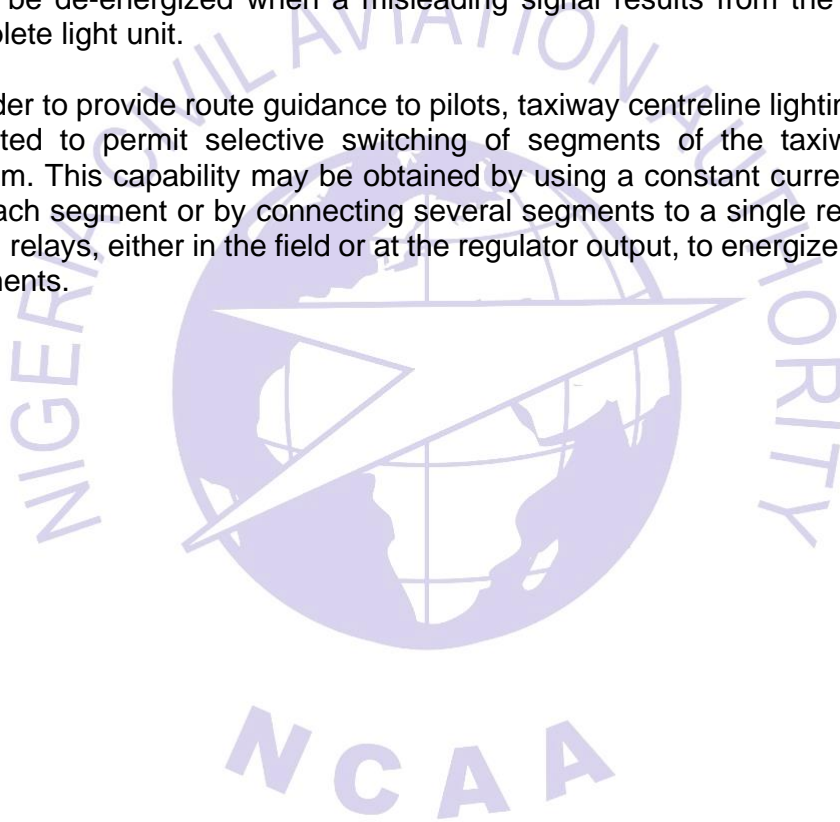


Figure 2-3: precision approach lighting system interleaving



- (l) Visual approach slope indicator systems are required to have two circuits per runway end when operated with an ILS system.
- (m) When the visual approach slope indicator system is a full PAPI or T-VASI and installed on both sides of the runway, the power to all light units on one side of the runway must be supplied by the same circuit. This arrangement ensures that should one circuit fail a complete pattern will be retained on the other side of the runway.
- (n) When approach slope indicators are installed on only one side of the runway as with the PAPI and AT-VASI, some of the lamps in each light unit are to be connected to one circuit and the remainder to the other circuit in order to maintain the integrity of the pattern. Hence, loss of one of the lamps within a light unit will result in reduced intensity. Visual approach slope indicator systems must be de-energized when a misleading signal results from the failure of a complete light unit.
- (o) In order to provide route guidance to pilots, taxiway centreline lighting would be circuited to permit selective switching of segments of the taxiway lighting system. This capability may be obtained by using a constant current regulator for each segment or by connecting several segments to a single regulator and using relays, either in the field or at the regulator output, to energize the desired segments.



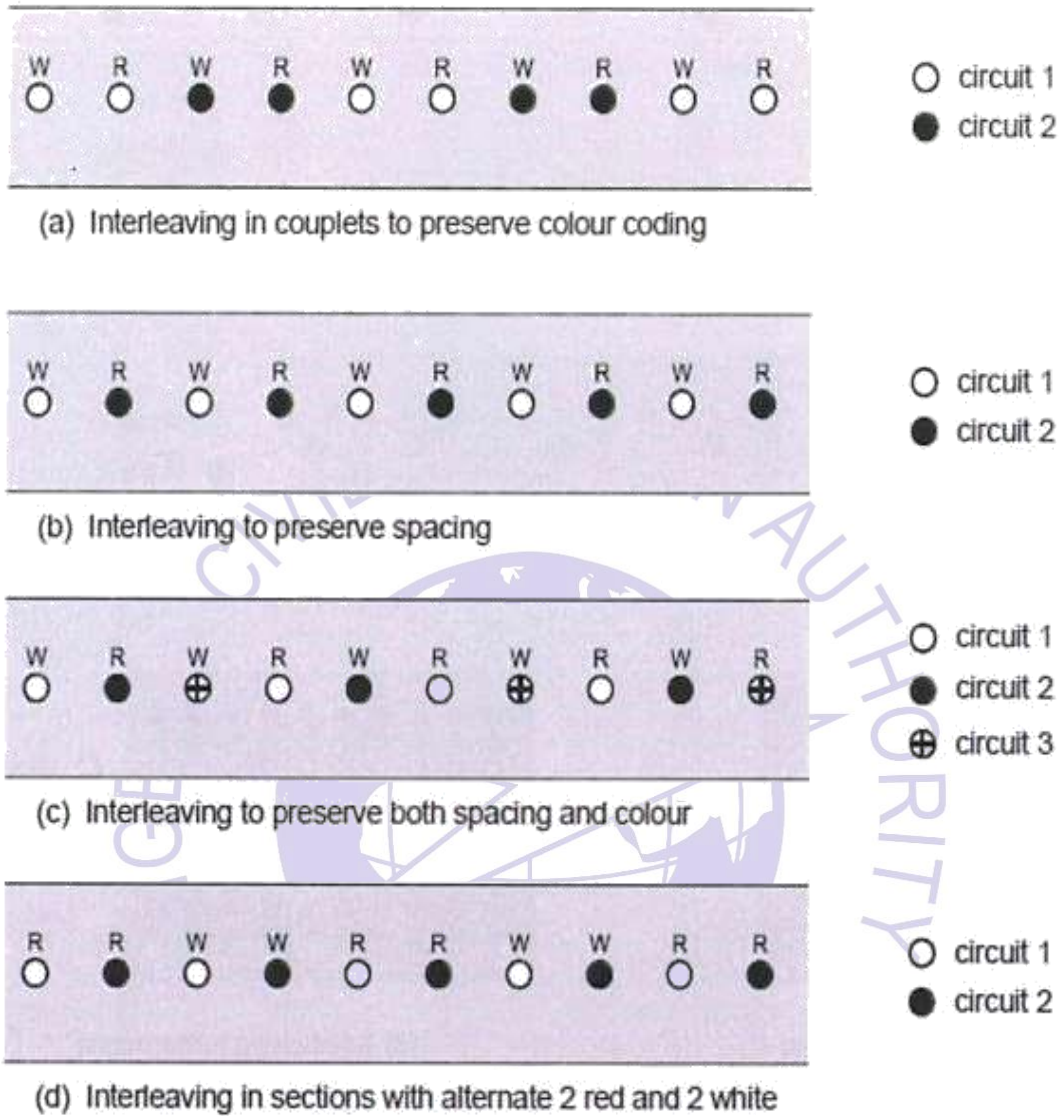
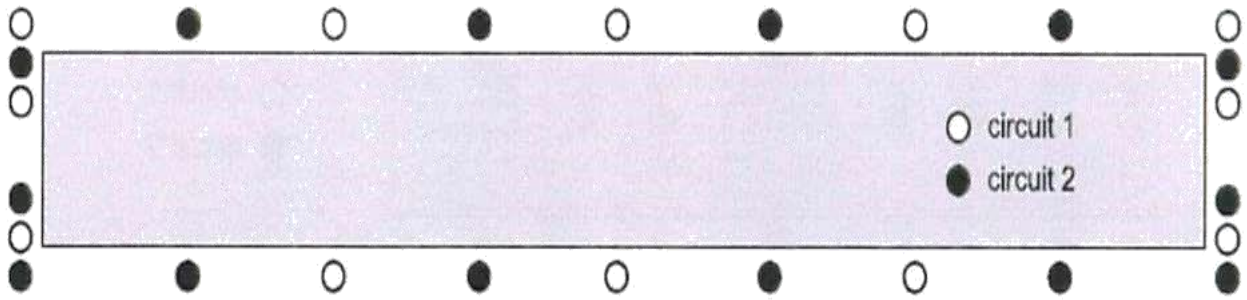
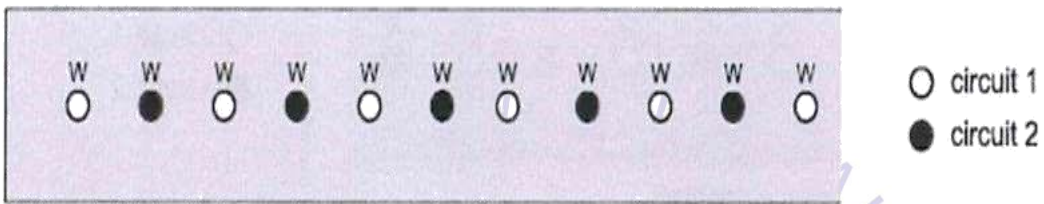


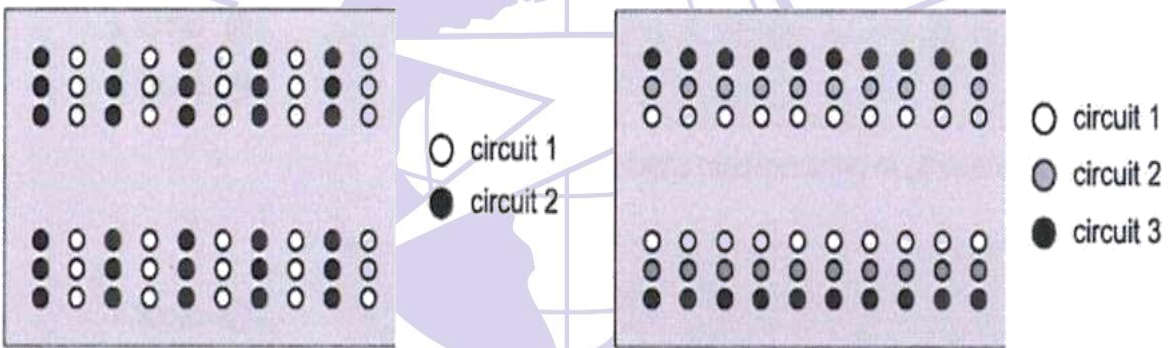
Figure 2-4: interleaving of color coded light



(a) Runway edge lighting



(b) Runway centreline (refer Figure 6-4 for coded section)



(c) Interleaving by barrettes with two circuits

(d) Interleaving by horizontal lines with three circuits

Figure 2-5: Runway edge, centre line and touch down zone lighting

2.2 Designing for integrity and reliability

- (a) The design and installation of aerodrome lighting systems can affect integrity and reliability in ways other than selection of components and interleaving of circuits.
- (b) Some of the features determined in the design decisions are:
 - (i) installing cables in conduits (ducts) instead of direct burial;
 - (ii) using inset lights instead of elevated lights in areas where surface traffic often collides with the light fixtures;
 - (iii) providing ground-wire circuits throughout the system to reduce the effects of high-voltage surges due to lightning strikes; and
 - (iv) equipping light fixtures with heating elements to eliminate moisture condensation, etc.
- (c) In order to ensure a high level of reliability, the designer has to take into consideration the environmental limitations of components of the system that are to be installed, e.g. equipment that has an operational range of up to +50 degrees Celsius should be installed indoors. In the case of electronic equipment such as constant current regulators and uninterruptible power supply equipment in the electrical vault, means for improved ventilation may be required.

3. CONTROL AND MONITORING OF AERODROME LIGHTING SYSTEMS

3.1 General Criteria

- (a) The requirement for monitoring aerodrome lighting systems applies to lighting installed on the manoeuvring area (approach, runway and taxiway lighting).
- (b) However, the aerodrome operator may provide a second control system for lighting in the apron area, such as floodlighting, apron taxiway lighting, aircraft stand taxi-lane lighting, aircraft stand manoeuvring guidance lights and visual docking guidance systems. This control panel enables operation of lighting on the apron to facilitate the flow of aircraft from taxiways of the manoeuvring area to the gate positions.
- (c) When provided, the graphics of the second control may be operated remotely to the operations/maintenance centre with a degree of interface between this panel and the one installed in the ATS tower.

3.2 Control Circuitry

- (a) The control circuitry for aerodrome lighting provides the means of switching on or off and of changing the intensity of the various lighting systems.
- (b) These controls may be manual or automatic.
- (c) The simplest control method is a switch at the power supply unit which is operated by a person to energize or de-energize the circuit. This control method might be used at small aerodromes with a reduced number of lighting system circuits. At large airports, a means of local control in the electrical vault could be provided as an alternate control point during emergencies. This local control could replicate the control in the ATC tower. An example of control/monitoring system is given in figure 3-1.

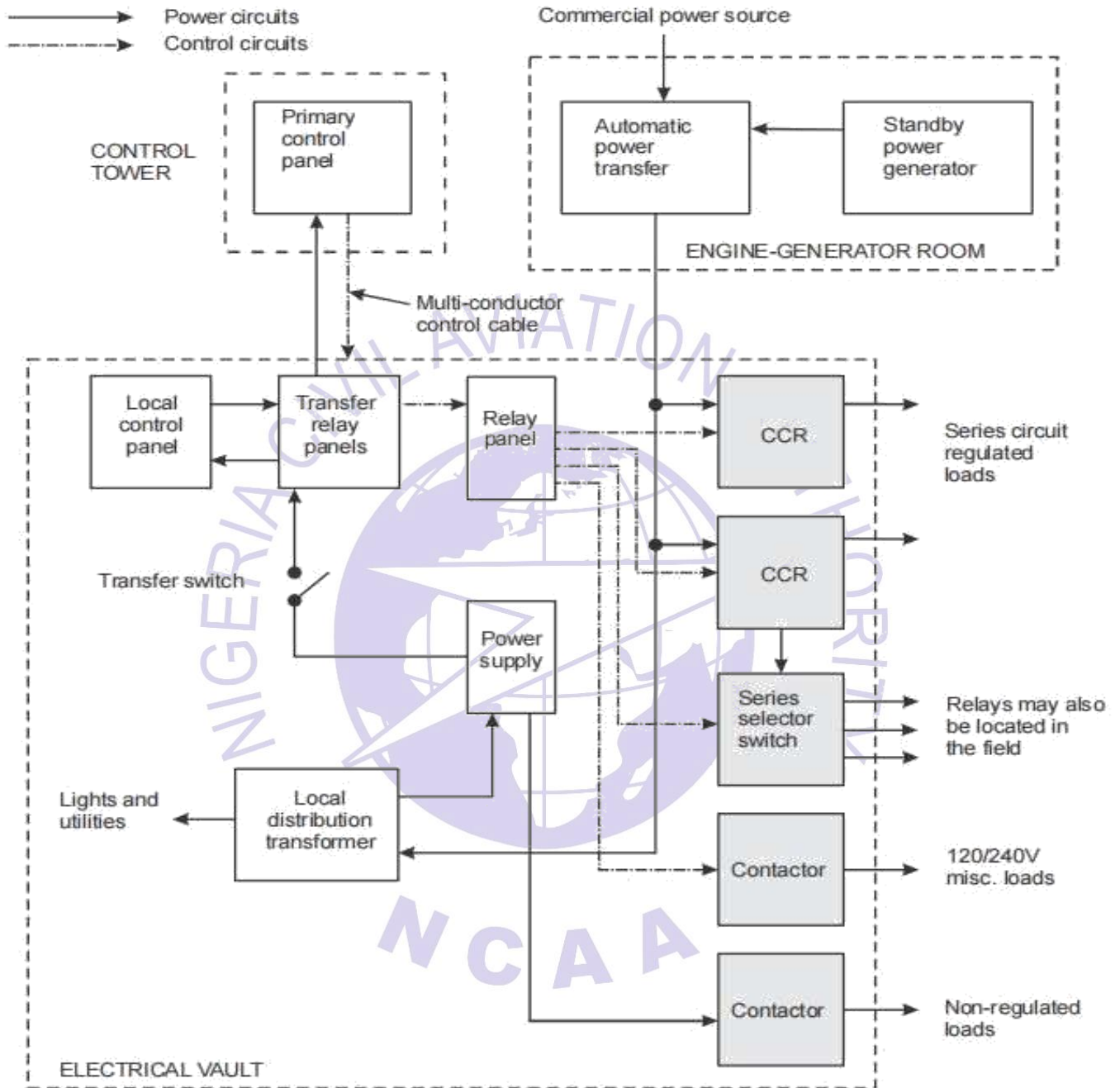


Figure 3-1: Traditional control/monitoring system

3.3 Monitoring of aerodrome lighting circuits

- (a) A system of monitoring is required to indicate the operational status of the lighting system. A desirable monitoring system is one which responds to the actual energizing of the lighting system in the field. Partial or incomplete monitoring systems can create a false sense of security. A monitoring system using sensors at the regulator output cannot detect other modes of failure such as obscuring by grass, or rubber deposit. Therefore, the daily field inspection remains a necessity.
- (b) The lighting systems are to be monitored for the following fault conditions:
- (i) loss of AC input power to the constant current regulator;
 - (ii) shutdown of the regulator due to operation of protective circuits;
 - (iii) a 10 per cent or greater drop in the volt-amperes (VA) delivered to the series circuit;
 - (iv) failure of the regulator to deliver the output current that corresponds to the brightness step selected; and
 - (v) failure of a preset number of lamps in the series circuit.
- (c) Those fault conditions which pertain to total circuit failure - that is, loss of the lighting to the pilot - are alarmed to the ATC. Those faults that are related to maintenance criteria, such as failure of a preset number of lamps, are indicated to an operations centre or to the maintenance centre. Where a lighting system is composed of two or more circuits, the failure of one circuit may be alarmed to ATC; although the pattern reduction is sufficient for aircraft use on an emergency basis, it is to be considered a system failure for continued operation.