Airfield Ground Lighting(AGL)

Air Field Lighting(AFL)

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Id card 8983

Airfield Ground Lighting(AGL)

Air Field Lighting(AFL)

Airpot had begun using Lights in the late 1920s, when landing fields were marked with rotating lights so they could be found after dark. In the early 1930s, airports installed the earliest forms of approach lighting. These indicated the correct angle of descent and whether the pilot was right on target. Their approach path was called the glidepath or glideslope. Gradually, the colors of the lights and their rates of flash became standard worldwide based on International Civil Aviation Organization (ICAO) standards. The Air Mail Service's intermediate, or emergency, landing fields that it established along the air route used rotating electric beacons and lights that were set around the perimeter of the field so Aircraft lighting systems **provide illumination for both exterior and interior use**. Lights on the exterior provide illumination for such operations as landing at night, inspection of icing conditions, and safety from midair collision

Introduction
Engineering Objective

Introduction & Introduction to Airfield Ground Lighting

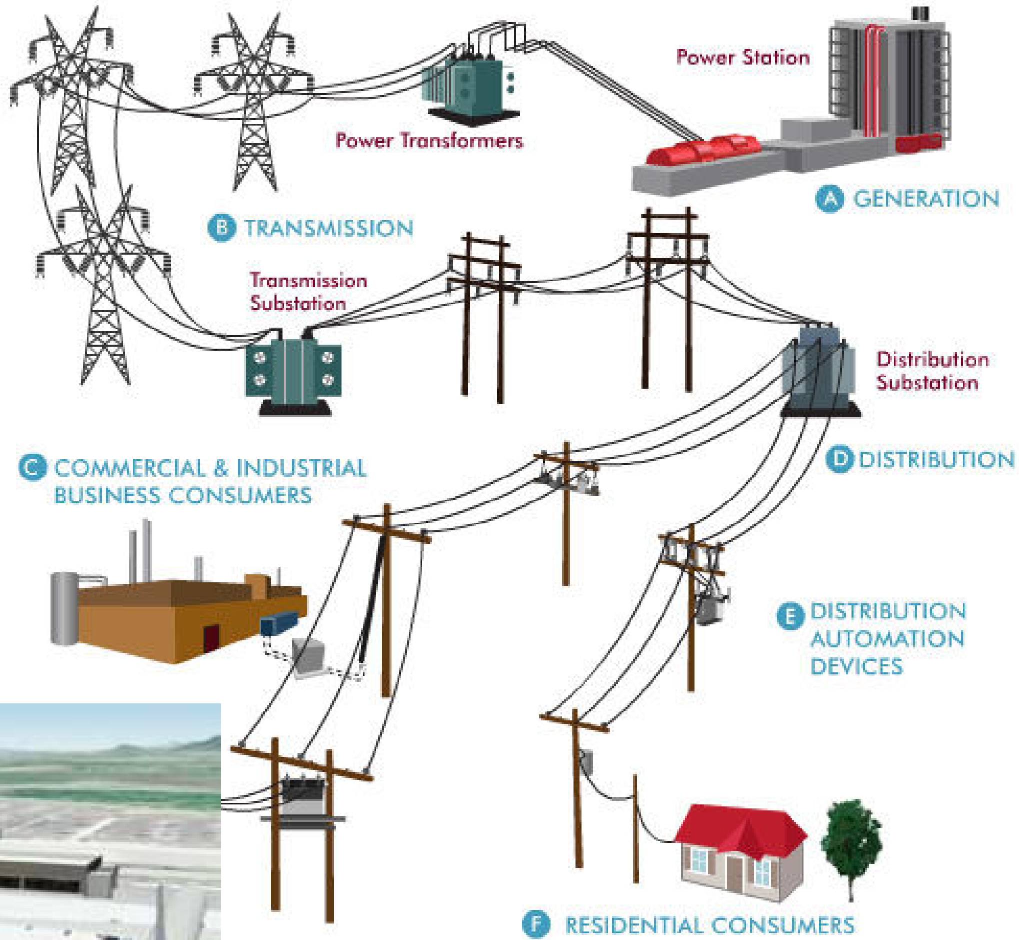
Electrical incoming Power Supply

Electrical incoming Power Supply

1. Primary power source: public or private network
2. Standby/Emergency power supply:

▪Diesel Generator Set

▪Uninterruptible Power Supply (UPS)



Components in AFL / AGL Series Circuits

Primary Circuit

CCR
Lightning Arresters
Output disconnecting Device
Primary Cable (screened or unscreened) Secondary
Primary Connectors (plug/socket or through---joint)
Series Isolating Transformer (Primary winding)

Secondary Circuit

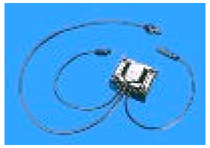
Isolating Transformer
(Secondary Winding)
Secondary Cable
Connection (plug/socket or through joints)
Light Fitting

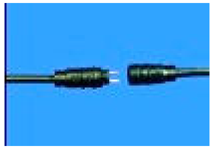
Other Components

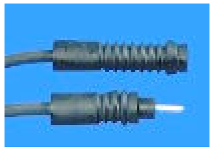
Earthing Network
Counterpoise system
Incoming Power supply system
Remote Control System

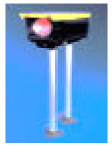
Now let us look at the Power Supply Technology

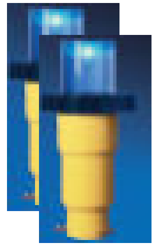
Airfield Lighting Control System (ALCS & ILCMS





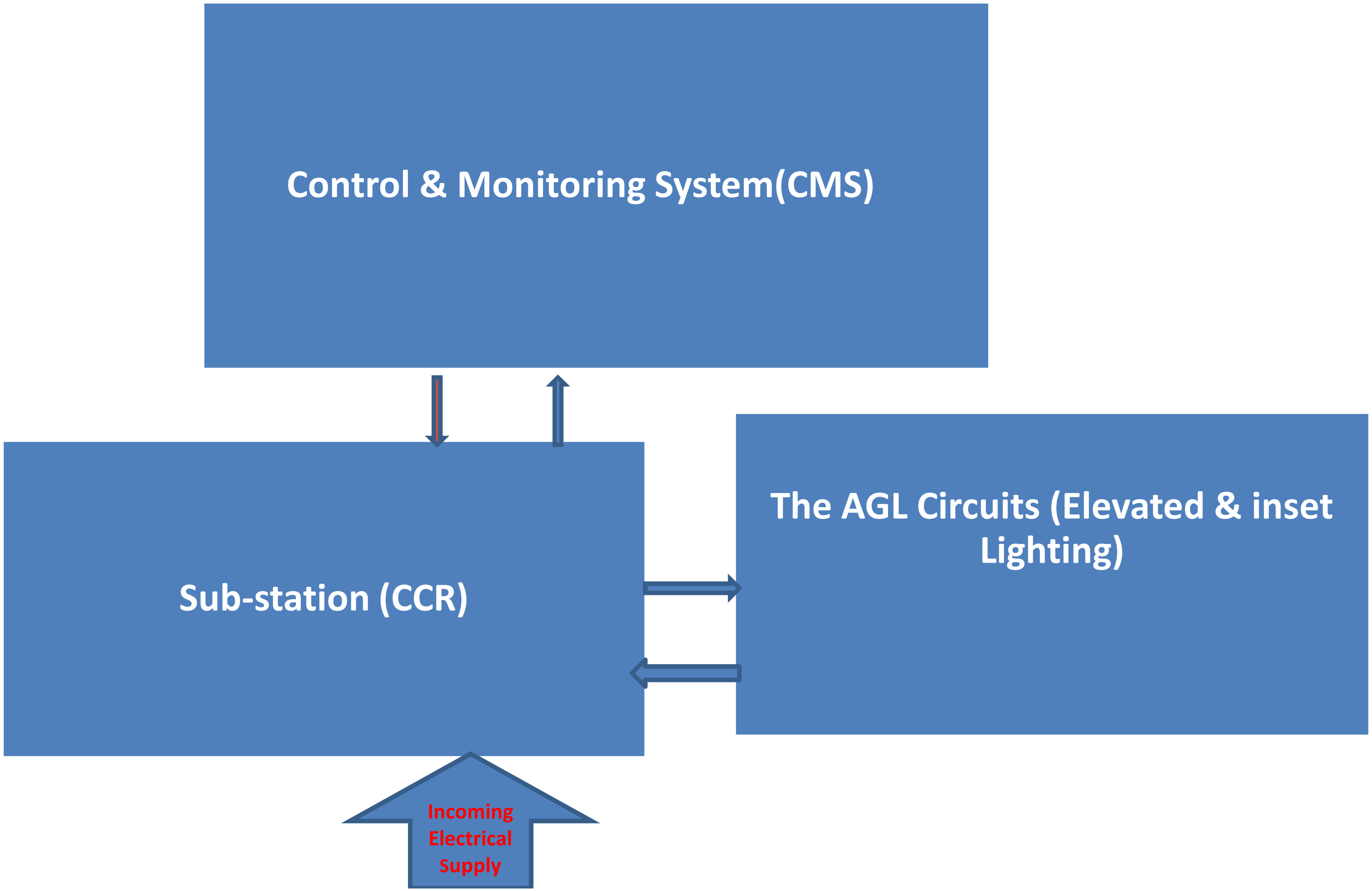






The basic principle of an AFL / AGL system

- Incoming electric



AFL/AGL outgoing Power Supply Constant Current Regulator

Thyristor bridge

Ferro resonance

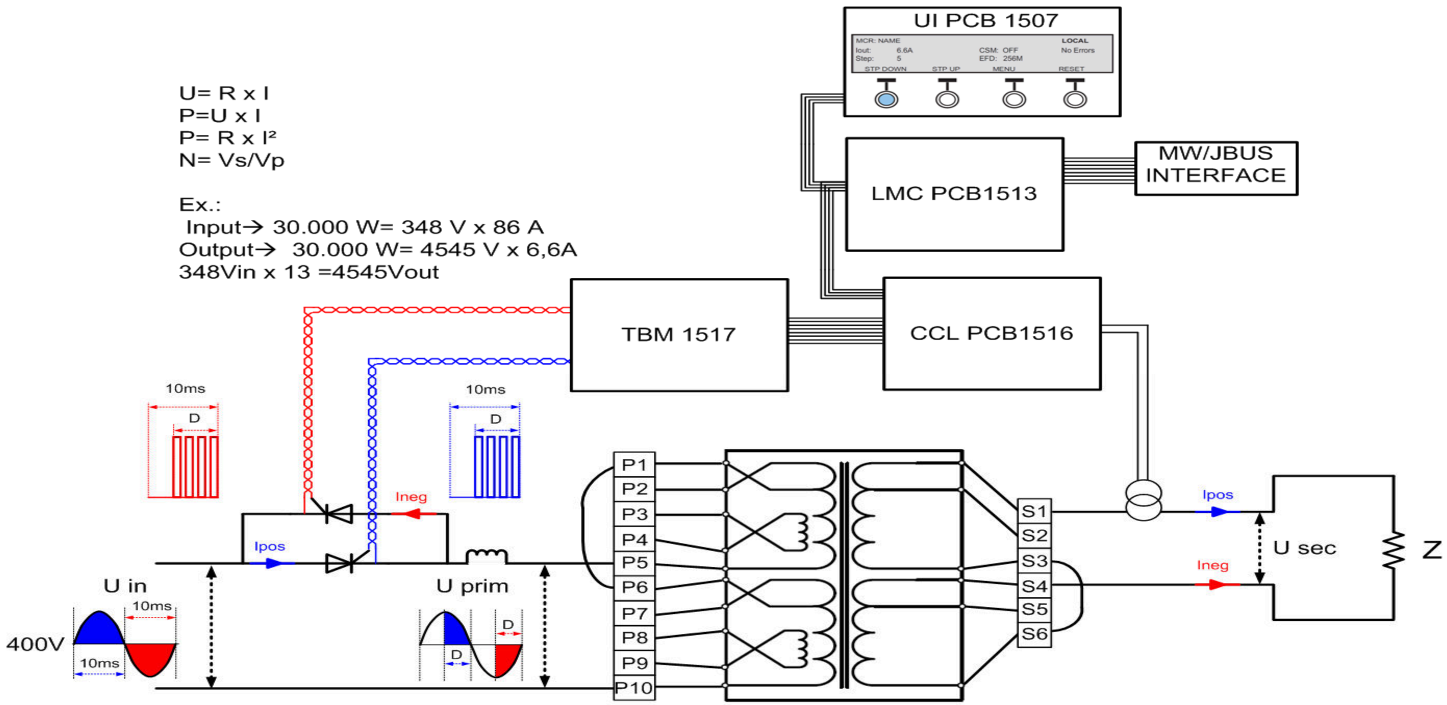
IGBT Low Harmonic

FAA markets

ICAO markets

Thyristor Constant Current Regulator

ADB Type MCR3 –Flow Diagram

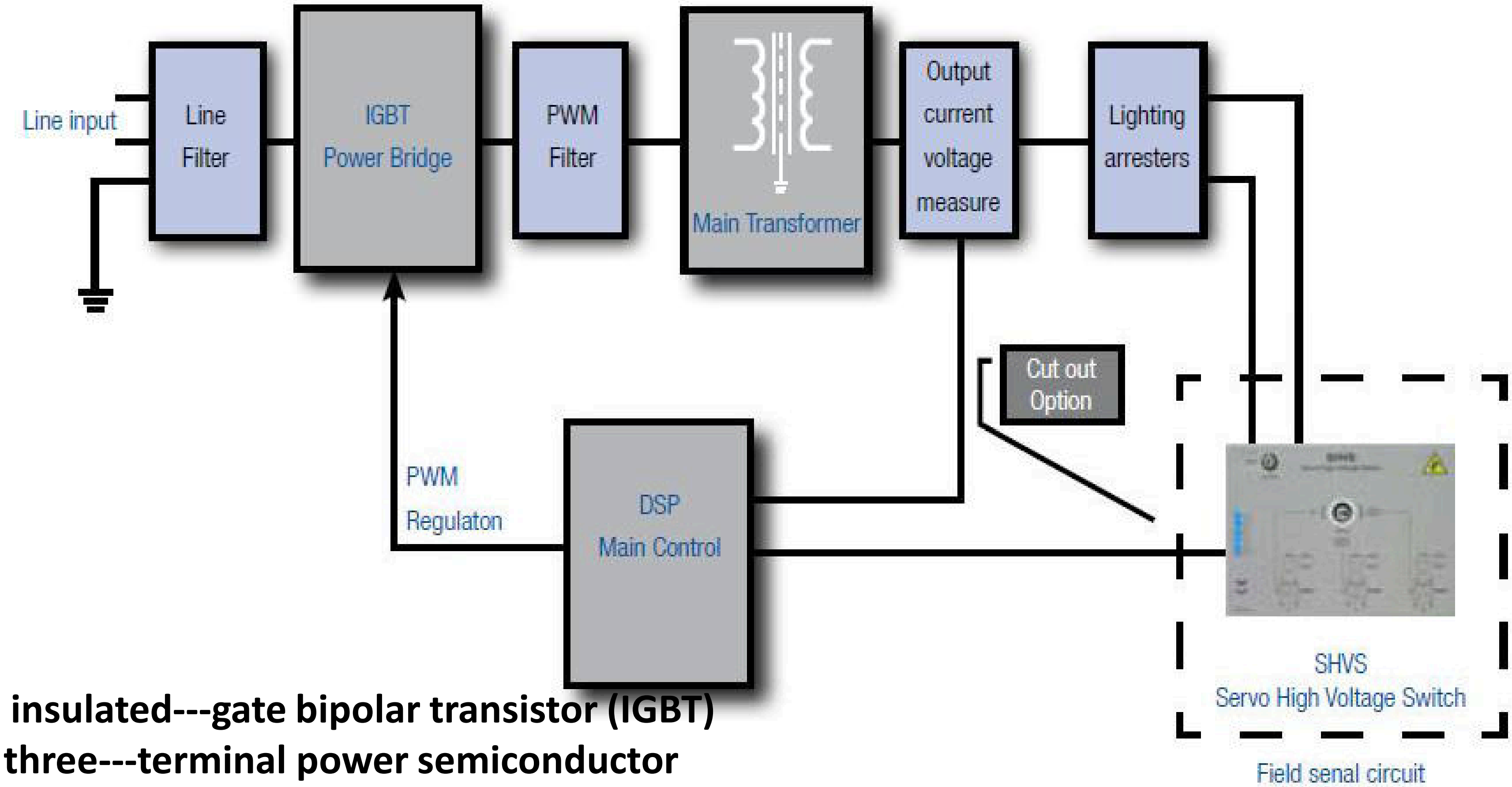


A thyristor is a solid-state semiconductor device with four layers of alternating P- and N-type materials used for high-power applications

IGBT Low Harmonic Constant Current Regulator

General Working

ADB Types CRE & VIS – Flow Diagram



The insulated---gate bipolar transistor (IGBT) is a three---terminal power semiconductor device primarily used as an electronic switch which, as it was developed, came to combine high efficiency and fast switching

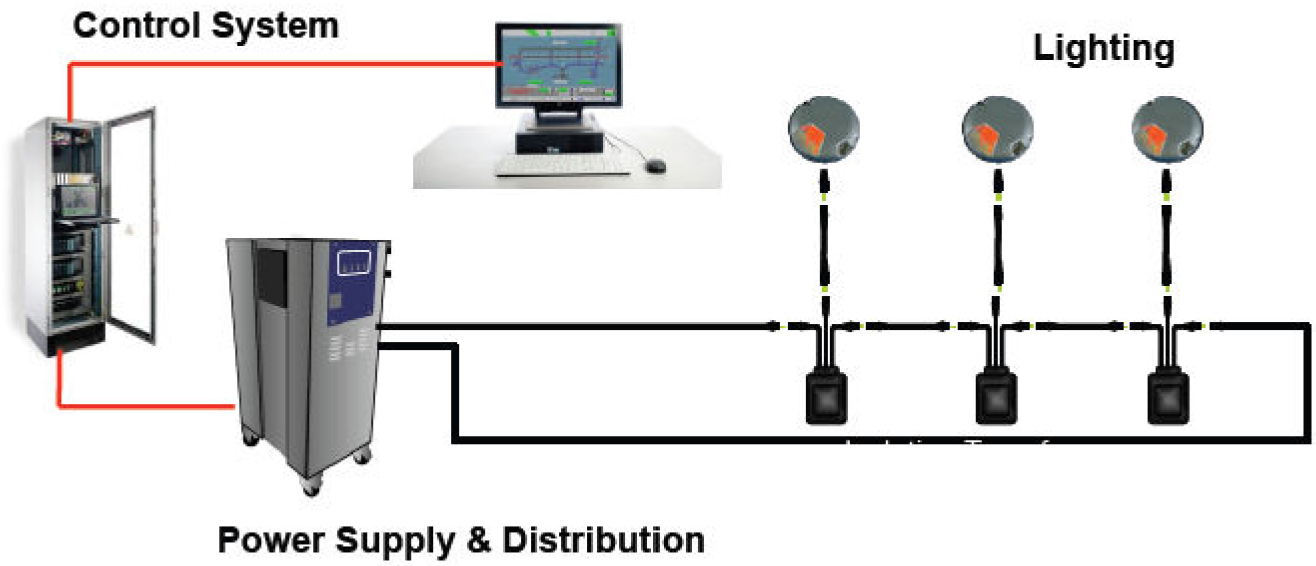
The AFL / AGL Series Circuits

So what is an AFL/AGL "Series Circuit"?

Definition :

An AFL/AGL series circuit starts at a power supply commonly called a Constant Current Regulator or CCR, and through a single cable passes through a series of isolating transformers and returns to the CCR. Each isolating transformer powers a light, sign or other device.

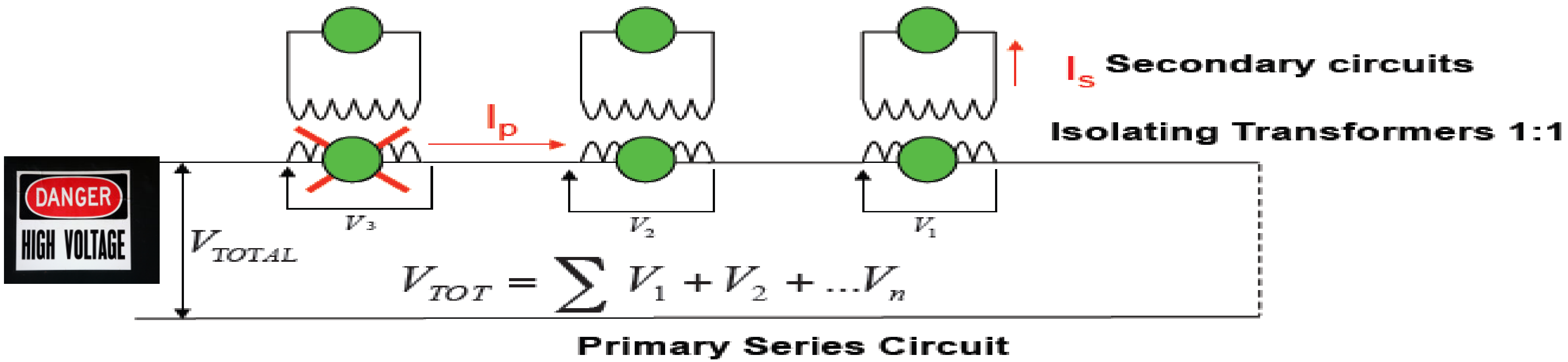
AFL/ AGL as a system



Introduction to the Series Circuit

100 x 45W=4500W

100 x 9W = 900W 1 x 200W = 200W = 5600W (or 5600VA) Therefore 5600VA ÷ 6.6A = 848.4V



- Constant current is maintained throughout the series circuit.
- Constant Current Regulator specially are designed for the supply of airport lighting series loops at various intensity levels.

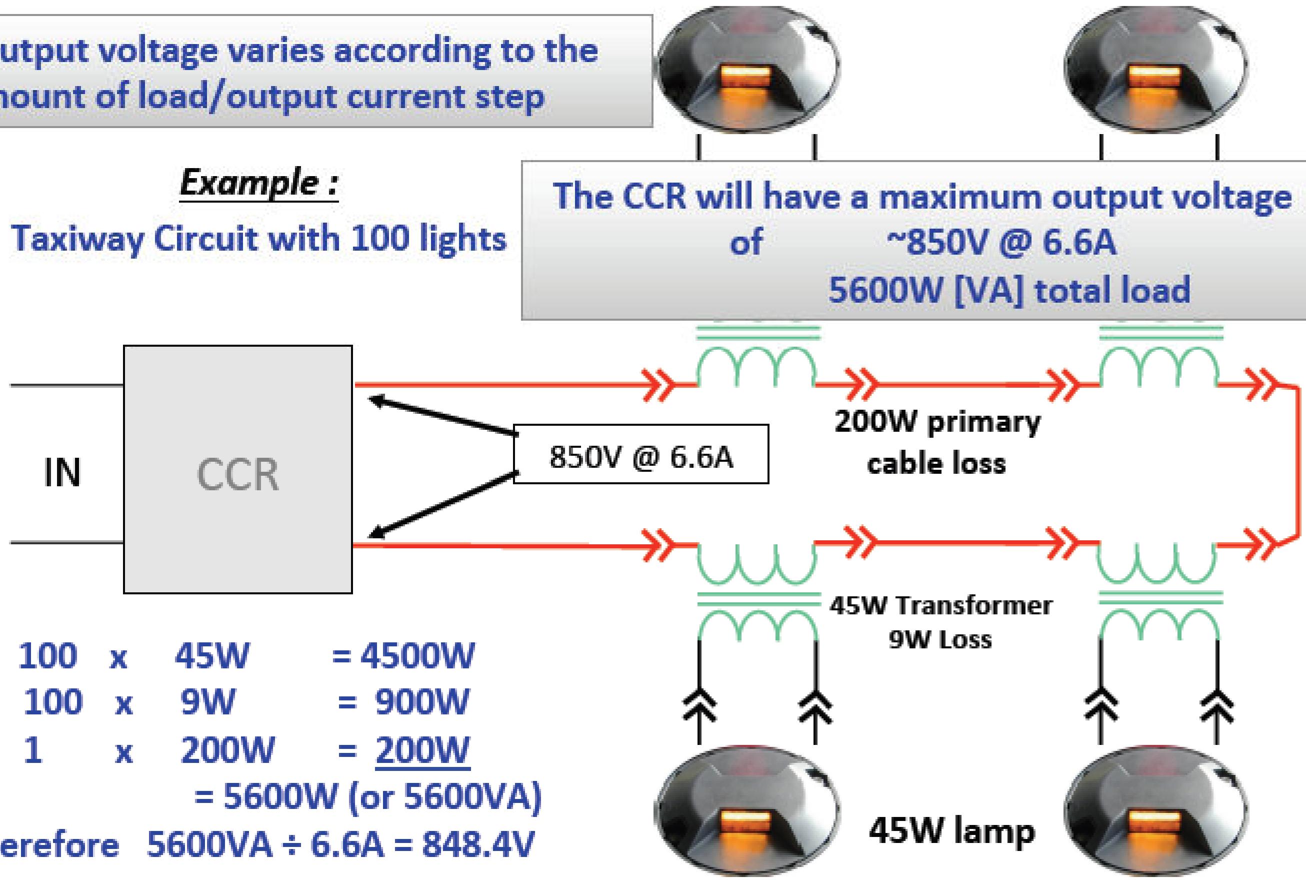
CCR output voltage varies according to the amount of load/output current step

Example :

Taxiway Circuit with 100 lights

The CCR will have a maximum output voltage of ~850V @ 6.6A

5600W [VA] total load



100 x 45W = 4500W

100 x 9W = 900W

1 x 200W = <u>200W</u>

= 5600W (or 5600VA)

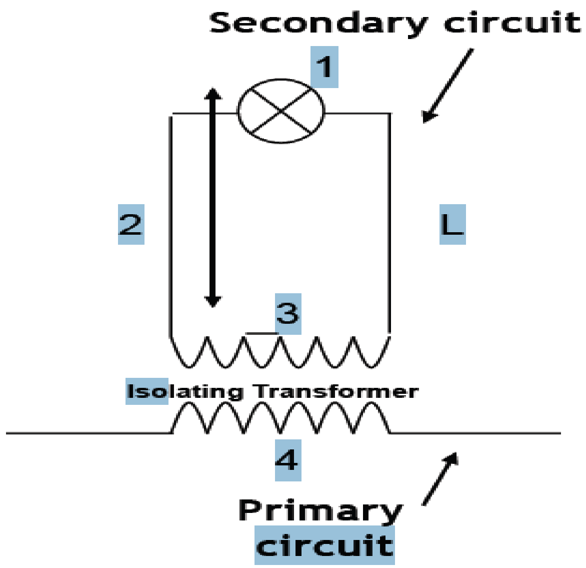
Therefore 5600VA ÷ 6.6A = 848.4V

Airfield Ground Lighting Engineering Objective EO installation awareness and Quality

Constant Current Regulator – Load calculation

1. Take for example a circuit using 45 Watt fittings. Then look at each individual isolating transformer and fitting.

So from drawing below : value of lamp 1 = 45 W



2.Length (l) from transformer to fitting = 30 m

If the section of wire used = $4mm^2$

- Resistance R in secondary circuit is

R *sec = 2*×ρ ×*l/s*

where resistivity ρ = 18 × 10-3 Ω mm^2/m

Therefore R sec = 0.27 Ω

Losses in sec. cable = I^2R= 6.6^2 x 0.27 = 11.76W

3. Total Power at secondary = sum of 1 & 2 = 56.76W

4. Power at primary side = power at secondary x 1.25 = 56.76 x 1.25 = 73.79 W

(1.25 represents the isolating transformer characteristics ie. efficiency coefficient)

5. If we take a series circuit containing 100 isolating transformers then:

Total power of transformers = 73.79 x 100 = 7379 W

6. If the total length of the primary circuit is 8000 m, and the section of cable is $6mm^2$ then

the losses in this primary circuit will be :

$I^2R = 6.6^2 \times 24 = 1045$ W where R *prim* $= \rho \times l / s = 24\ \Omega$

7. Total load on Regulator = sum of 5 + 6 = 8424 W

Introduction

What is an Airfield / Aerodrome ?

For the Recovery (Landing), Support & Take---off of Air Vehicles (Aircraft)

What are the key aspects to establish Airfield Facilities with respect to the Aircraft's operations ?

- 1. From the Air to the Ground (Runway) – Landing ! ***RUNWAY***

Lighting

From the Runway to the Terminal/Apron for Replenishment ***TAXIWAY***

- ***Lighting***
- 3. From the Terminal/Apron to the Runway for Take---off ***TAXIWAY***
- ***Lighting***
- 4. From the Runway o the Sky --- Take---off ! ***RUNWAY***
- ***Lighting***

International Categories of Operation

RVR (Rwy Visual Range)

Instrument Non---instrument

Precision / Non---Precision :

CAT 1 --- RVR @ 550 meters

CAT 2 --- RVR @ 300 meters

CAT 3A \ --- RVR @ 175 meters

3B --- RVR @ 50 meters

3C --- RVR @ N/A (not applicable**)**

Note : Annex 14 Vol 1 --- Edition 6 Issued : 2013

ICAO Requirements for Category I, II & III Lighting Systems

SYSTEM	CAT I	CAT II	CAT III	Remarks
APPROACH LIGHTS	X	X	X	
APPROACH SIDE ROWS	-	X	X	
FLASHING SYSTEM	X	X	X	Between Threshold and 300 m crossbar:only in CAT I
RTIL	X	X	X	
PAPI	X	X	N.M.	May be switch off in CAT III
THRESHOLD	X	X	X	
RUNWAY EDGE	X	X	X	
RUNWAY CENTERLINE	-	X	X	
TOUCH DOWN ZONE	-	X	X	
RUNWAY END	X	X	X	
RAPID EXIT TAXIWAY IDENTIFICATION LIGHTS	-	X	X	
RAPID EXIT TAXIWAY CENTERLINE	-	X	X	
TAXIWAY EDGE LIGHTS	X	X	X	Optional in the straight section if taxiway centerline installed
TAXIWAY CENTER LINE	-	-	X	
STOP BARS	-	X	X	
LEAD-ON LIGHTS	-	X	X	
RUNWAY GUARD LIGHTS	X	X	X	
INTERMEDIATE HOLDING POINT	-	-	X	
SIGNS	X	X	X	
WINDCONE	X	X	X	
BEACONS	COND.	COND.	COND.	Depends on the environment of the airport

1-Elevated lights

- ***Elevated approach***
- ***Elevated runway***
- ***Elevated stopway***
- ***and Elevated taxiway lights***

shall be frangible.

2-Light fixtures inset

- ***in the surface of runways***
- ***Stopways***
- ***taxiways***
- ***and aprons***
- shall be so designed and fitted as

to **withstand** being run over by the wheels of an aircraft without damage either to the aircraft or to the lights themselves.

Light intensity and control

Shall be

Note.— In dusk or poor visibility conditions by day, lighting can be more effective than marking. For lights to be

effective in such conditions or in poor visibility by night, they must be of adequate intensity. To obtain the required intensity,

it will usually be necessary to make the light directional, in which case the arcs over which the light shows will have to be

adequate and so orientated as to meet the operational requirements. The runway lighting system will have to be considered

as a whole, to ensure that the relative light intensities are suitably matched to the same end. (See Attachment A, Section 16,

and the Aerodrome Design Manual (Doc 9157), Part 4).

-

- **APPROACH LIGHTING SYSTEM**

- **approach lighting system cat I**
  — runway edge lights
  — runway threshold lights
  — runway end lights

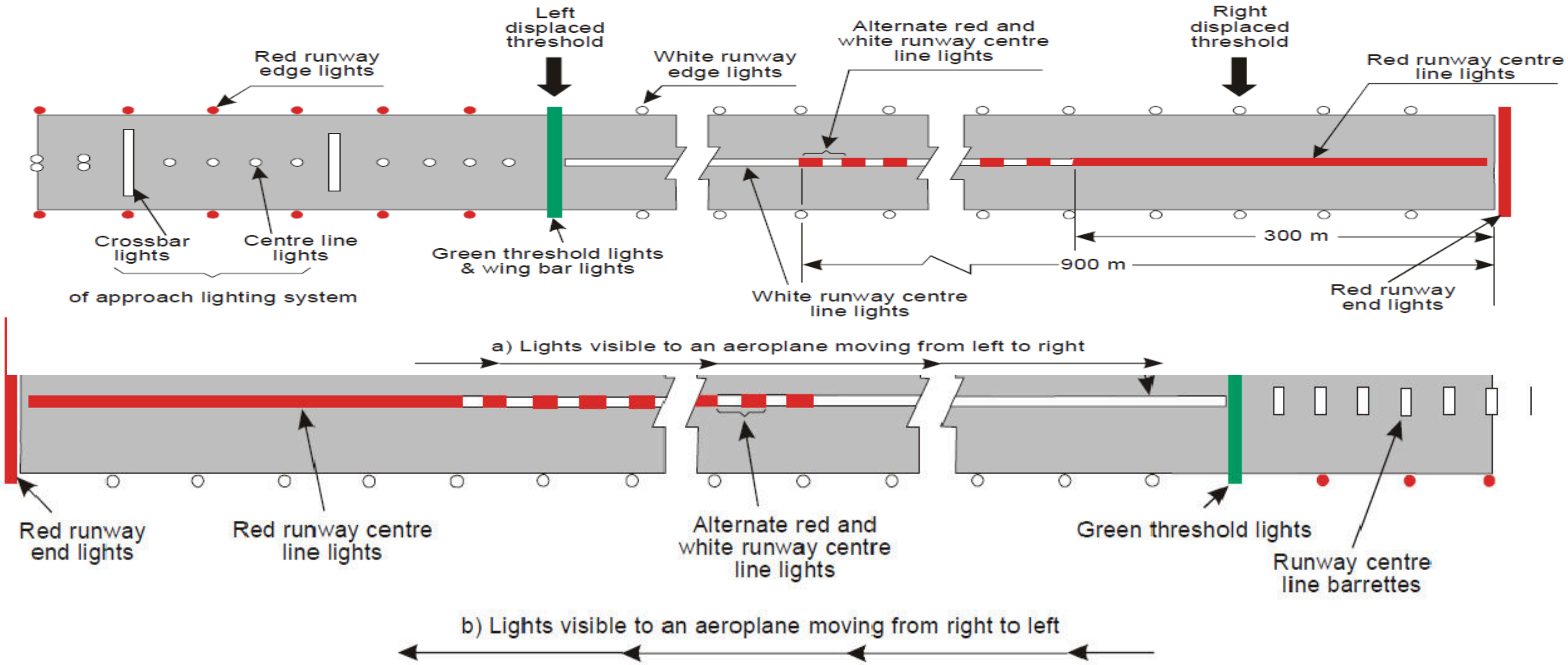
approach lighting system cat II and cat III

- approach lighting system;
- — runway edge lights
- — runway threshold lights
- — runway end lights
- — runway centre line lights
- — runway touchdown zone lights and
- — taxiway centre line lights.
- Aeronautical beacons

Separate intensity controls or other suitable methods

shall be provided to ensure that the above systems, when installed, can be operated at compatible intensities

Runway Edge (Side Row) Lights



Runway edge lights

*1. Should be provided on a runway intended for take-off with an operating minimum below an RVR of the order of **800 m** by day**.***

2. Shall be placed along the full length of the runway and shall be in **two parallel rows** equidistant from the centre line

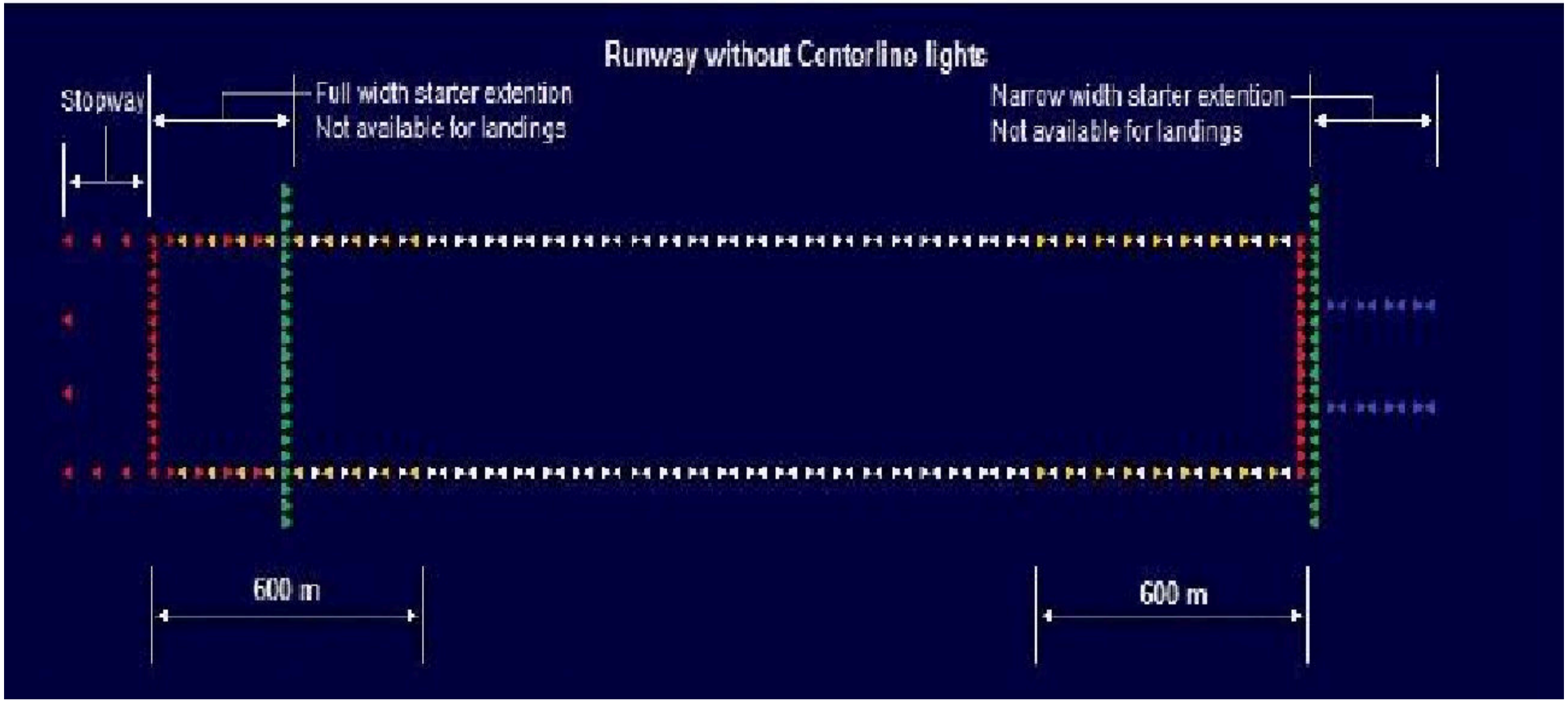
3. Runway edge lights shall be fixed lights showing variable **white**, except that:

a) in the case of a displaced threshold, the lights between **the beginning of the runway and the displaced threshold shall show red** in the approach direction; and

b) a section of the **lights 600 m or one-third of the runway length**, whichever is the less, at the remote end of the runway from the end at which the take-off run is started, may show yellow.

4. The runway edge lights shall show at all angles in azimuth

Runway edge lights



Precision Approach Path Indicator

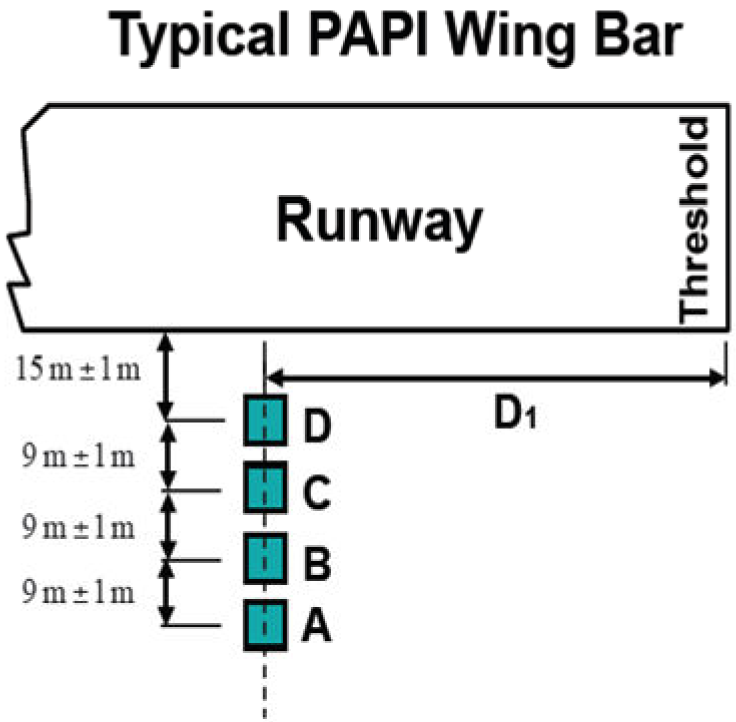
A visual approach slope indicator system will enable the pilot to …

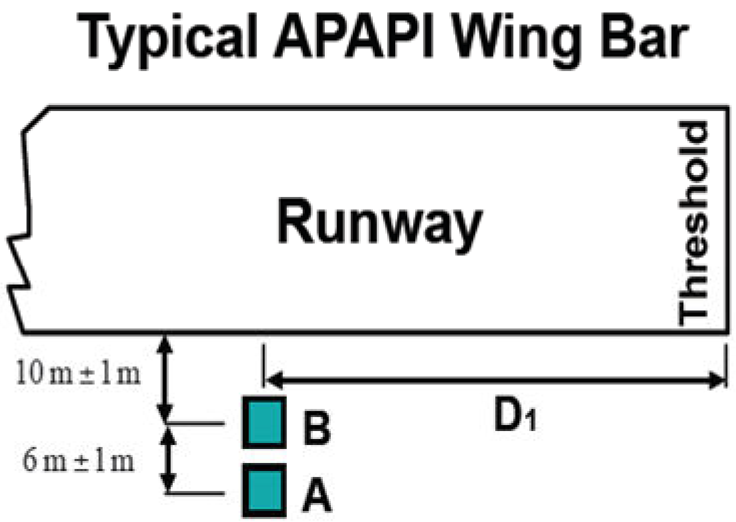
- Know his precise position on the approach slope.
- Detect immediately any deviation from the correct path.
- Give clearance over approach obstacles.

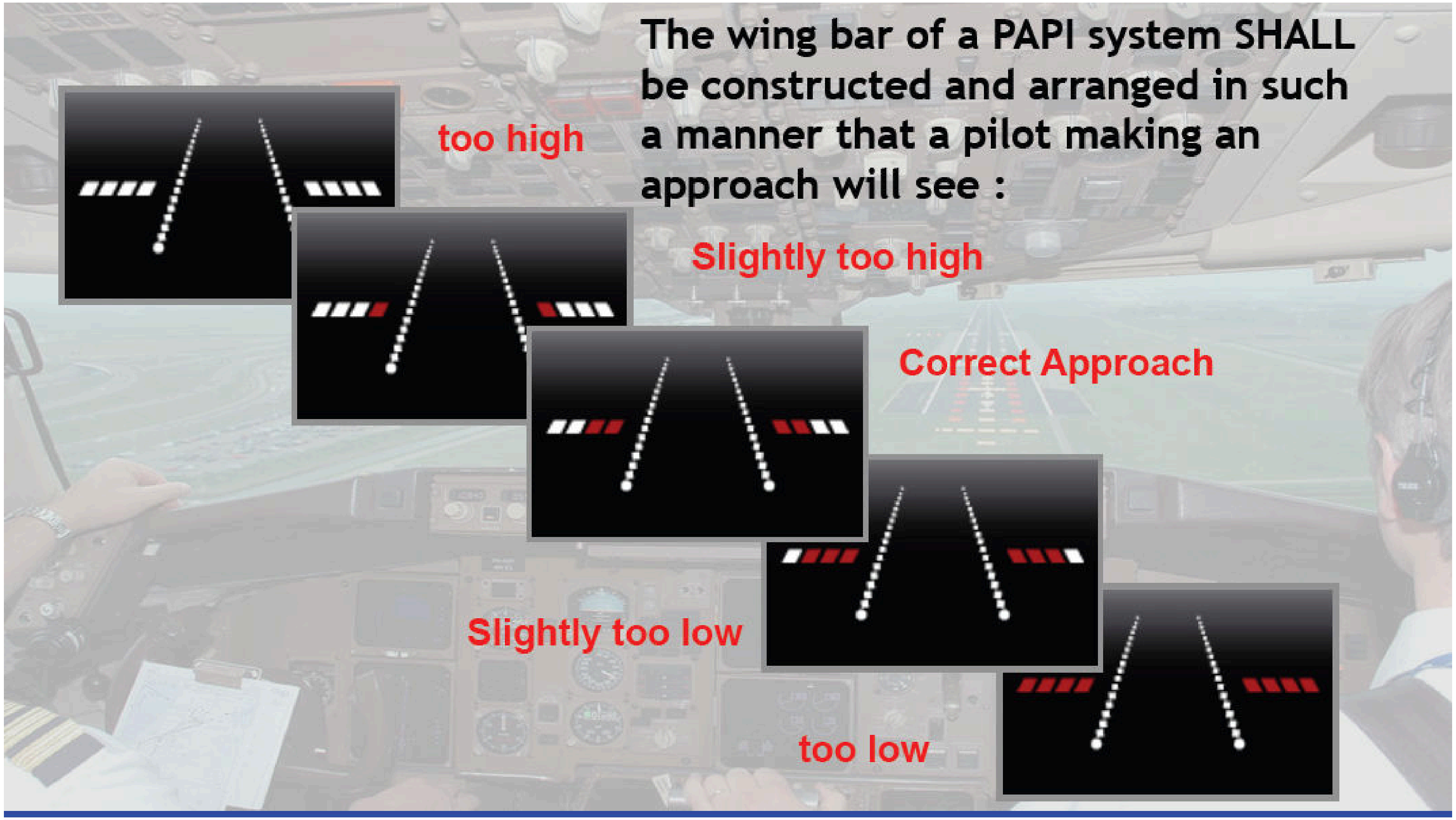
The standard visual approach slope indicator system is basically used in two configurations :

- **PAPI** : a four projector box system.
- **APAPI** : a two projector box system.

PAPI – Lay---outs & Elevation Setting

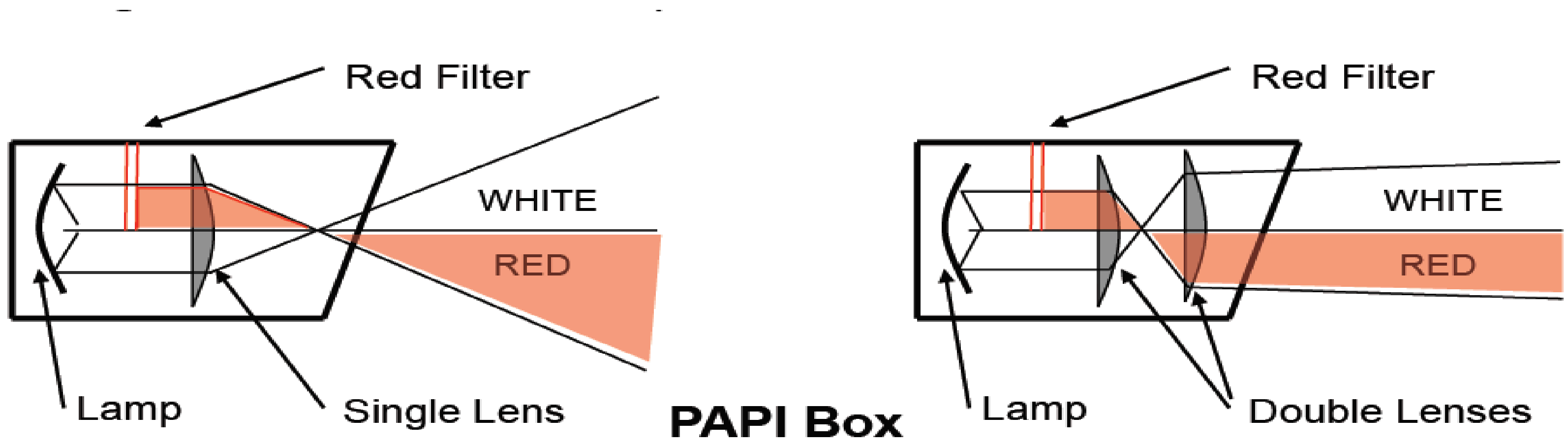




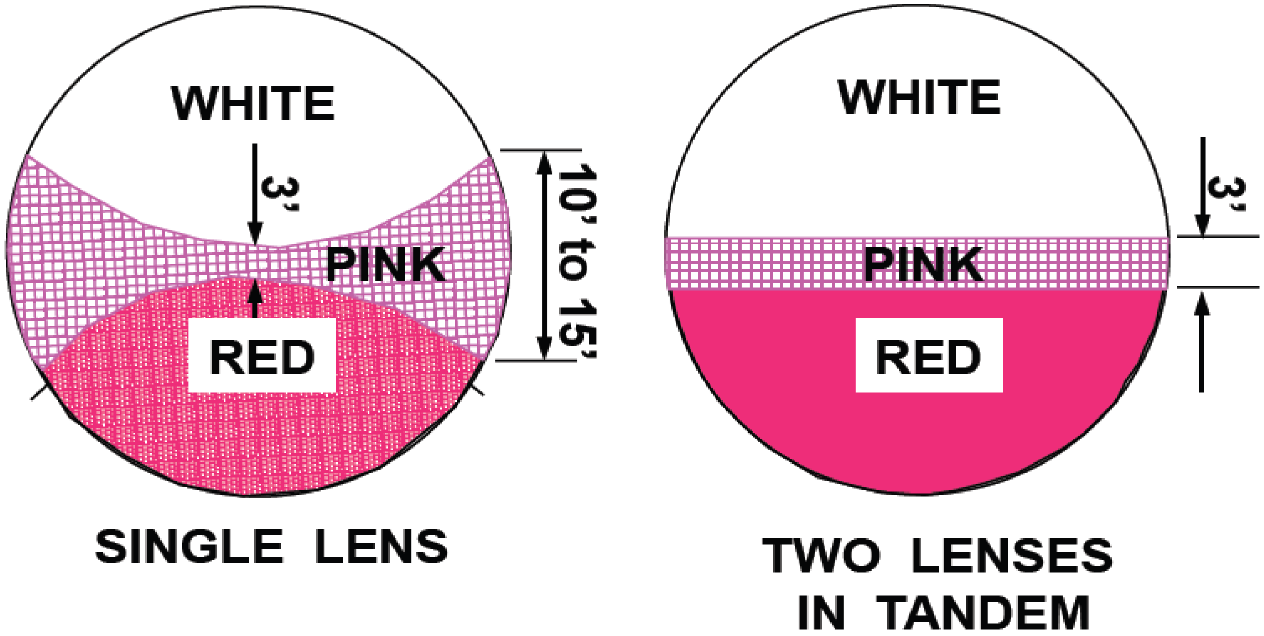

The wing bar of a PAPI system SHALL be constructed and arranged in such a manner that a pilot making an approach will see :
too high
Slightly too high
Correct Approach
Slightly too low
too low

Design of **PAPI Units** ---General

- **PAPI systems utilize a set of 'two colour' high intensity light projector(s) :**
- The upper half of the light beam from each projector is white and the lower half red.
- The transition sector (Pink Zone) between the two colors occurs over a very mall angle (**within 3 minutes of Arc).** This 'sharp transition' is an integral feature of the PAPI system



Transition Sector Sharpness (Commonly known as the 'Pink Zone')



Notice the difference at the edges of the beam

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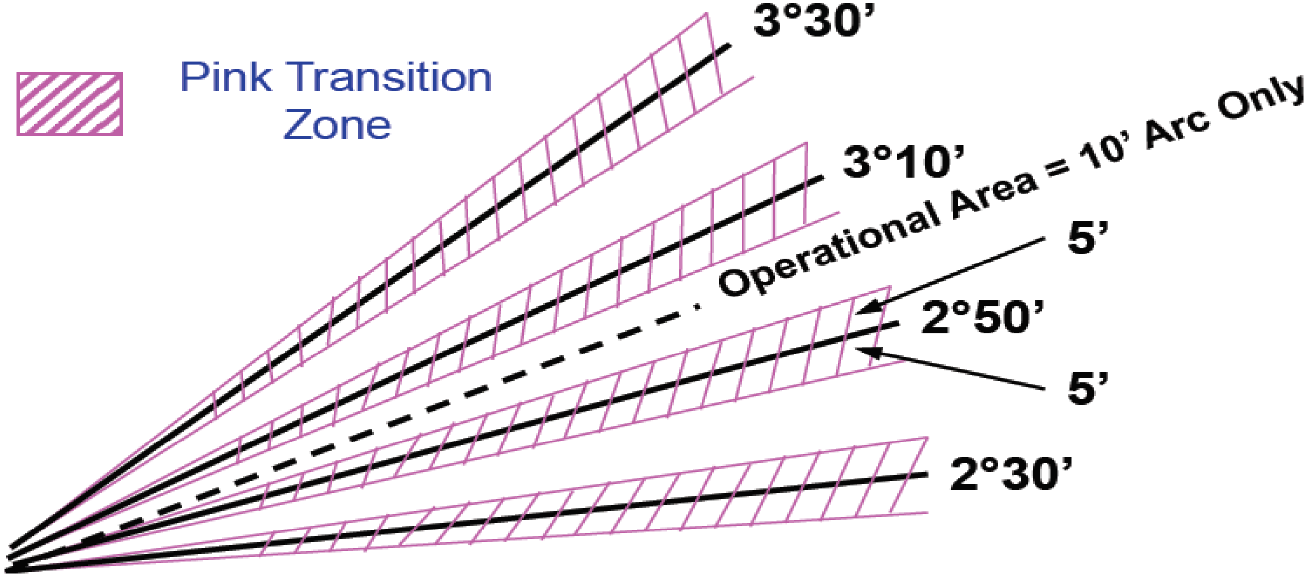
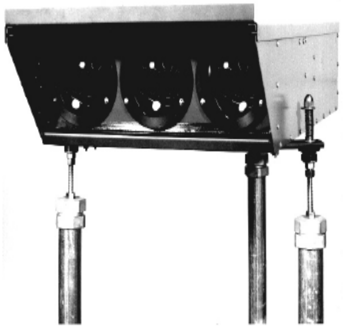
Transition Sector Sharpness

- **Single Lens set---up** : **Due to optical distortion and deterioration, the transition sector is expanded to 10’ at the edge of the beam, the width of The on---slope approach channel is reduced**



Number of light channels


3-Lamp Light Unit

Number of legs

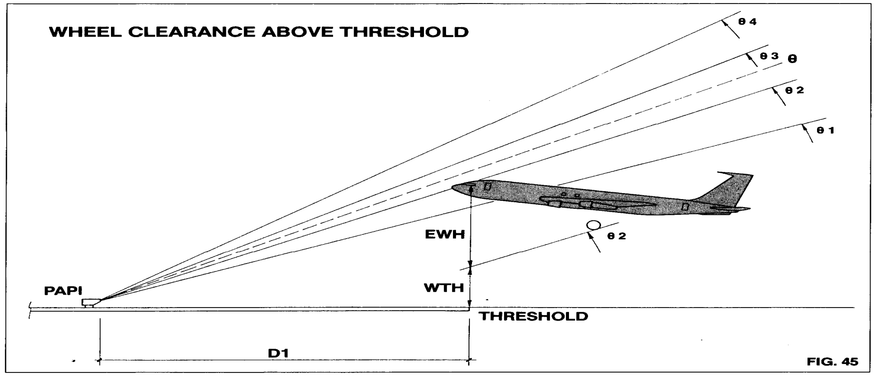
Detailed Calculation of PAPI Location

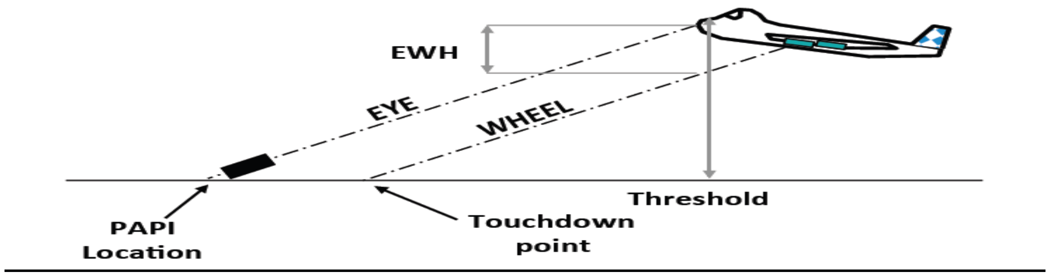
D1 = (EWH +WTH) cotg (θ 2 − 2')

EWH =
(Eye To Wheel Height)

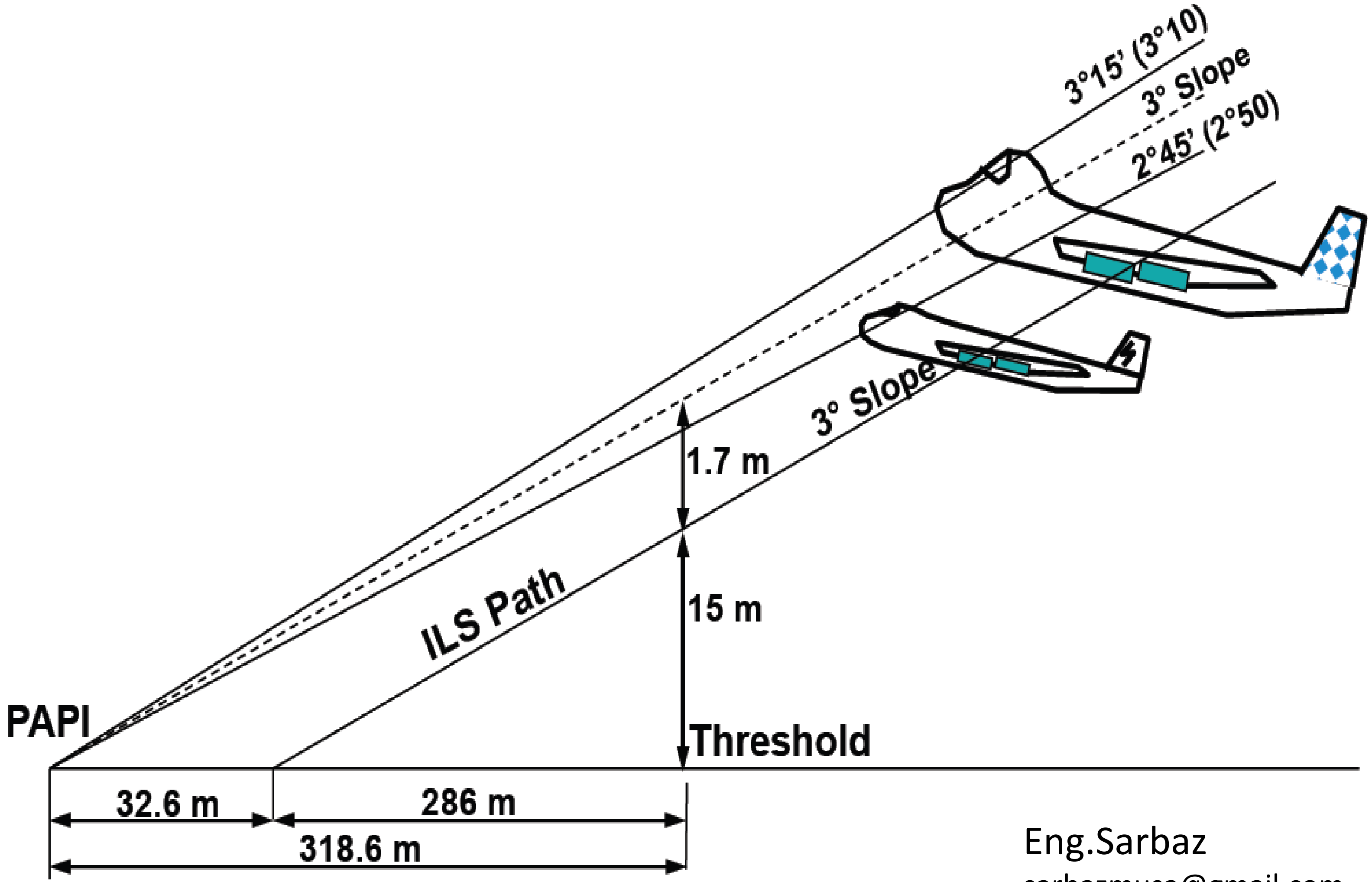
WTH =
(Wheel to Threshold Height)

D1 =
Distance of PAPI from threshold





Calculation of PAPI Location



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The diagram gives the typical eye-- to---aerial and the eye---to---wheel height for various aeroplanes in approach altitude.

Attachment 1

Table A6-1. Vertical distances between critical points on aircraft at maximum pitch attitude (VREF) (ILS)

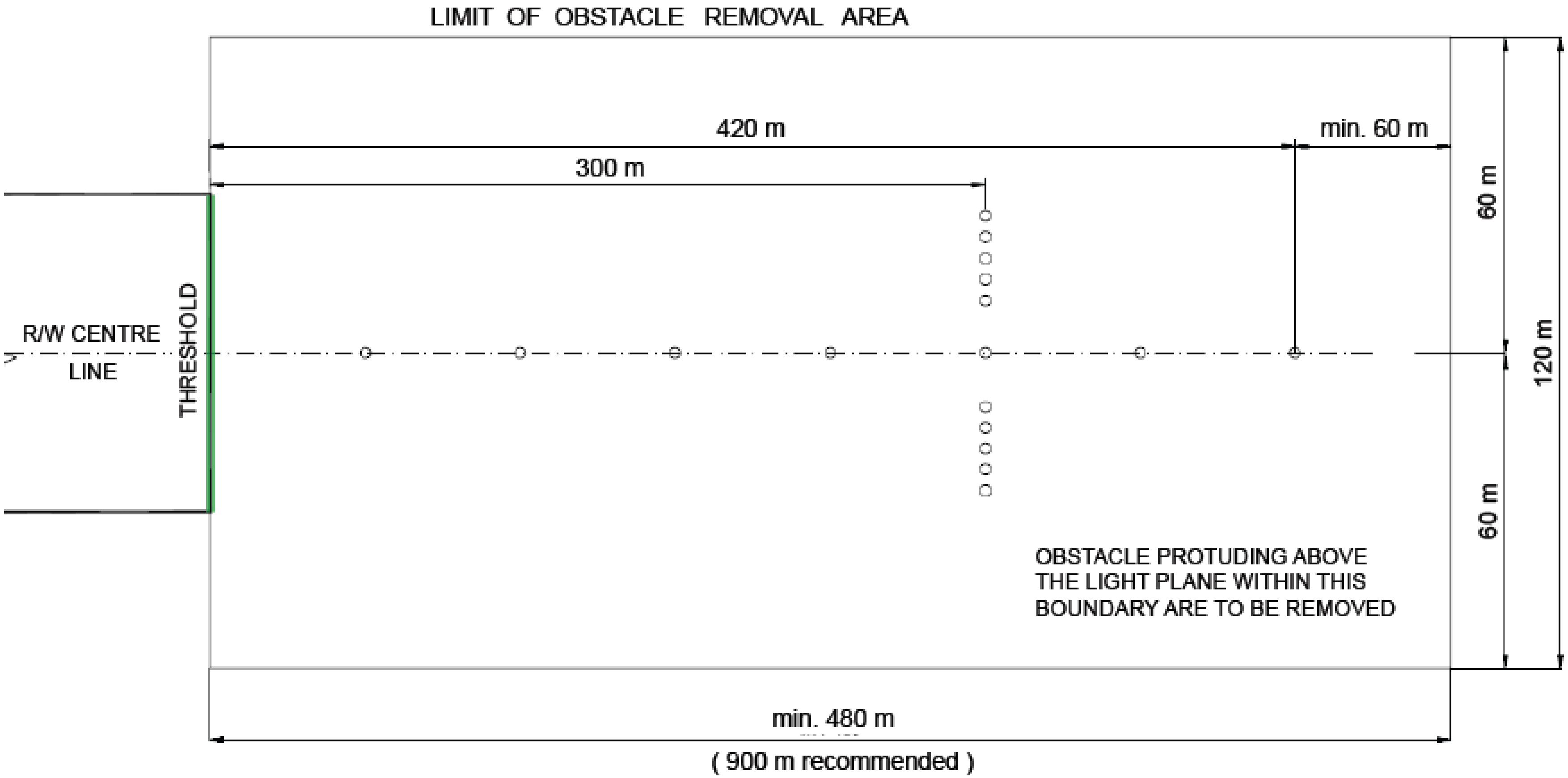
	2.5 degree glide slope						3.0 degree glide slope					
Aircraft Model	FD Pitch (deg) Flap Setting	Eye path to ILS beam (feet) H2	ILS beam to wheel path (feet) H	Eye path to wheel path (feet) H1	ILS antenna above wheels (feet) H3	Pilots Eye above wheels (feet) H4	FD Pitch (degree)	Eye path to ILS beam (feet) H2	ILS beam to wheel path (feet) H	Eye path to wheel path (feet) H1	ILS antenna above wheels (feet) H3	Pilots Eye above wheels (feet) H4
B737-900 w/Winglets	2.7 30	1.0	17.4	18.4	14.5	15.7	2.2	1.0	17.4	18.4	14.0	15.2
B747-400 B747-400ER B747-400ERF	5 25	21.0	23.4	44.4	19.4	40.3	4.5	21.0	23.4	44.4	18.6	39.4
747-8I	4.6 25.0	21.0	24.6	45.5	19.9	40.8	4.1	21.0	24.6	45.6	19.0	39.8
747-8F	4.4 25.0	21.0	24.2	45.2	19.6	40.4	3.9	20.9	23.3	44.2	18.6	39.4
B757-200	5.9 25	6.1	22.5	28.6	19.2	25.5	5.4	6.1	22.5	28.6	18.5	24.9
B757-300	4.2 25	6.2	21.8	28.1	17.9	24.3	3.7	6.2	21.8	28.1	17.1	23.6
B767-200 B767-200ER	5.6 25	6.6	23.9	30.6	20.8	27.6	5.1	6.6	23.9	30.6	20.1	27
B767-300 B767-300ER	3.7 25	6.8	22.6	29.4	19.0	26.0	3.2	6.8	22.6	29.4	18.3	25.3
B767-400	3.7 25	6.8	24.6	31.4	20.5	27.1	3.2	6.8	24.6	31.4	19.6	25.3
B777-200 B777-200ER	3.5 25	12.9	21.4	34.2	17.3	29.9	3.0	12.9	21.4	34.3	16.5	29.0
B777-200LR	3.7 25	12.9	21.7	34.6	17.6	30.2	3.2	12.9	21.7	34.6	16.8	29.4

approach lighting system;

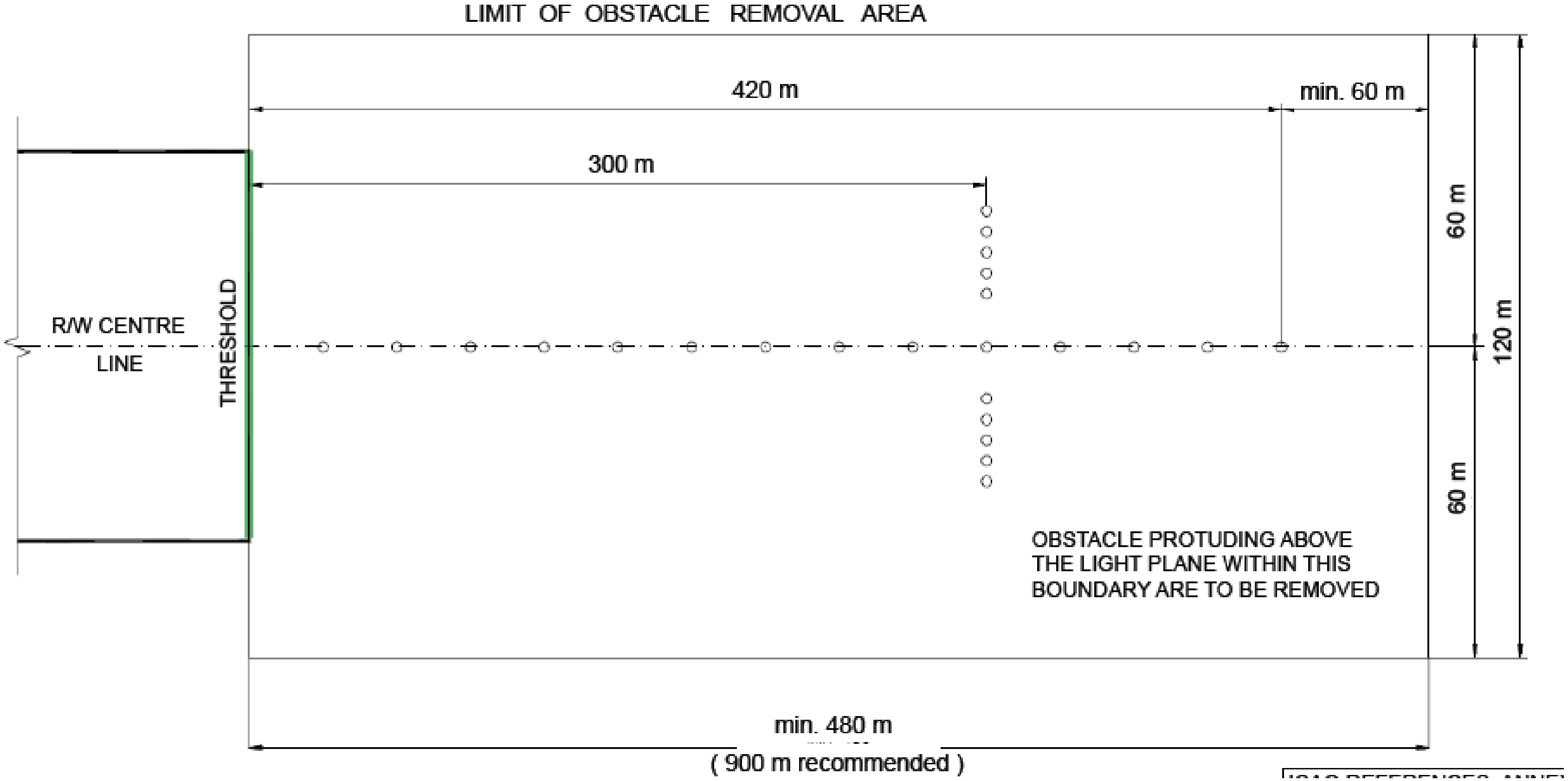
Approach Lighting provides visual guidance to pilots approaching an airfield:

1. *A simple approach lighting system*
2. Non-precision approach runway
3. Precision approach runway category I
4. Precision approach runway categories II and III

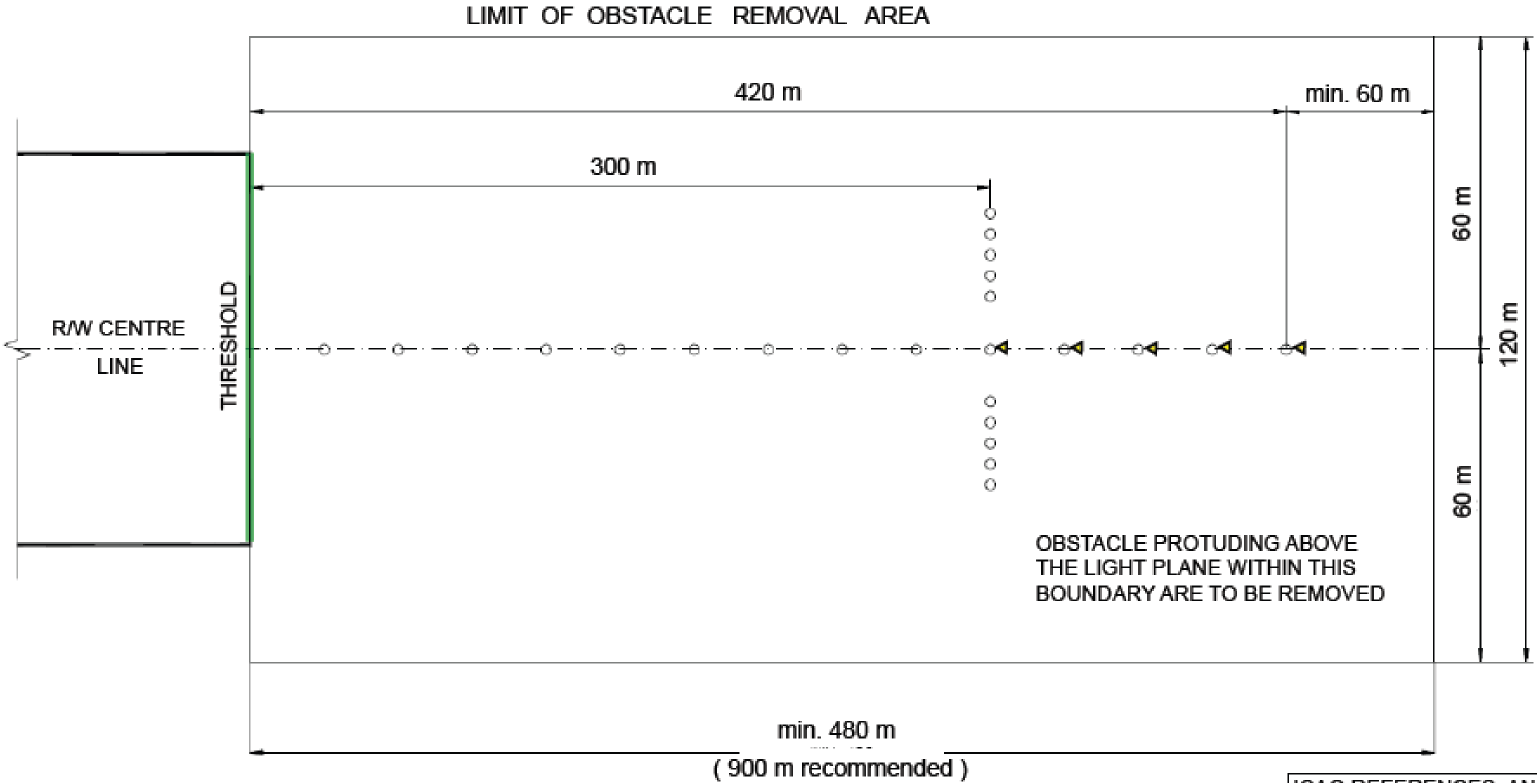
Simple Approach Lighting System - 17 Lights



Simple Approach Lighting System - 24 Lights



Simple Approach Lighting System - 24 Lights + 5 Flashing Lights



ICAO REFERENCES: ANNEX 14 – VOL 1
ATTACHMENT A. FIG. A-5 AND
§ 11.2 & 11.3

Simple approach lighting system

A simple approach lighting system shall consist of a row of lights on the extended centre line of the runway

extending, whenever possible, over a distance of not less than 420 m from the threshold with a row of lights forming a

crossbar 18 m or 30 m in length at a distance of 300 m from the threshold.

At locations where identification of the simple

approach lighting system is difficult at night due

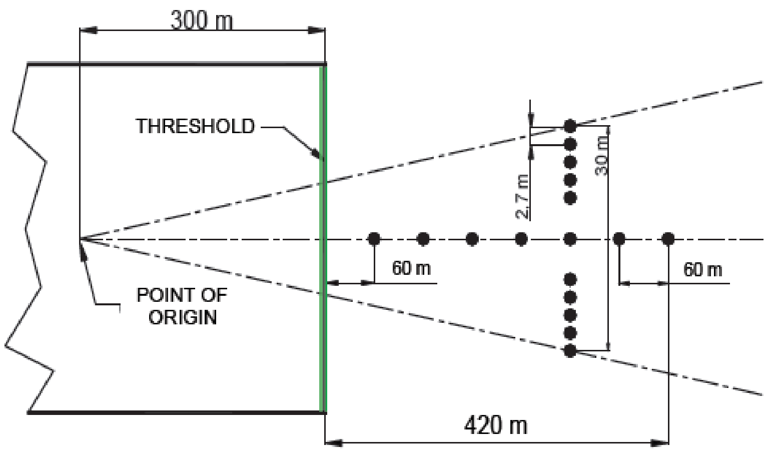
to surrounding lights, sequence flashing lights

installed in the outer portion of the system may

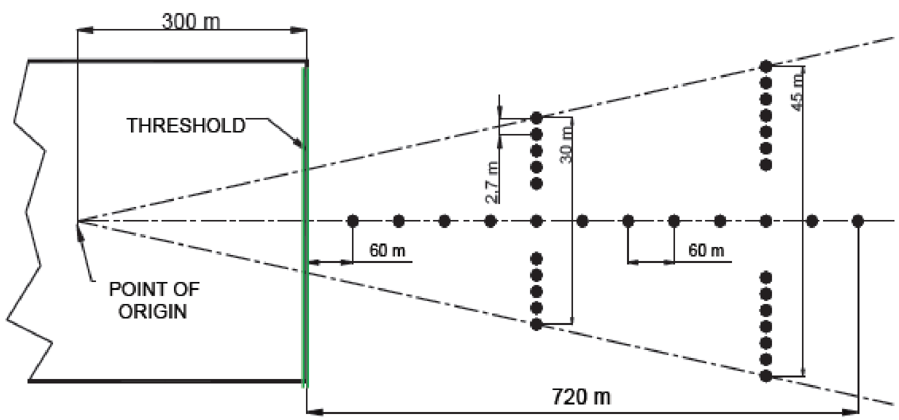
resolve this problem.

Simple approach lighting system

Simple Coded Approach Lighting System - CALVERT

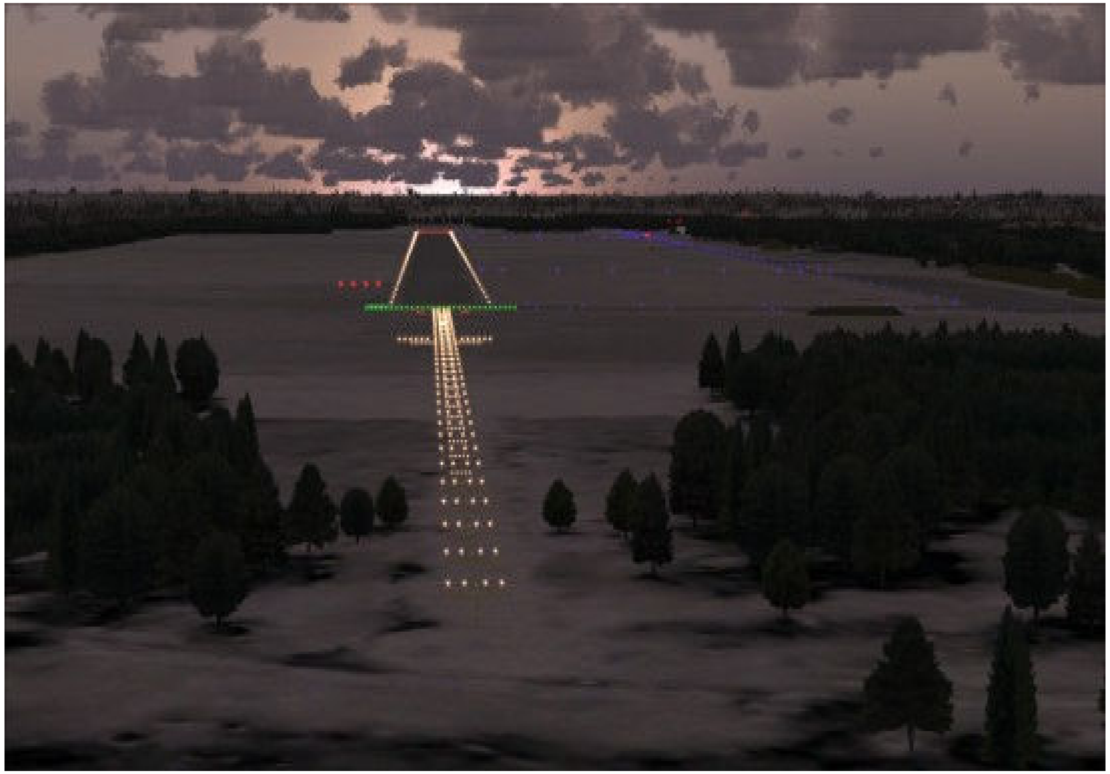


SIMPLE CALVERT APPROACH SYSTEM (420 m)



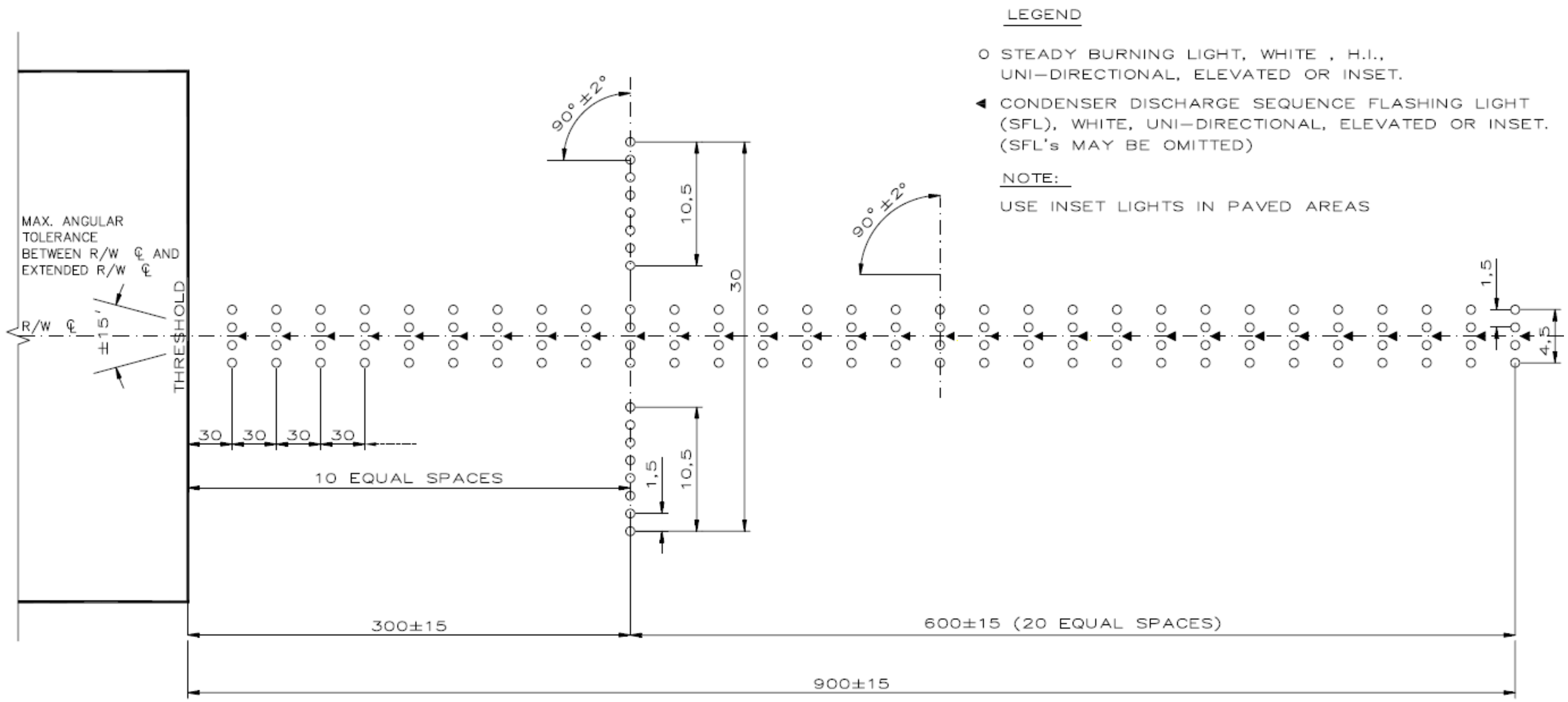
SIMPLE CALVERT APPROACH SYSTEM (720 m)

Precision Approach Cat. I lighting system

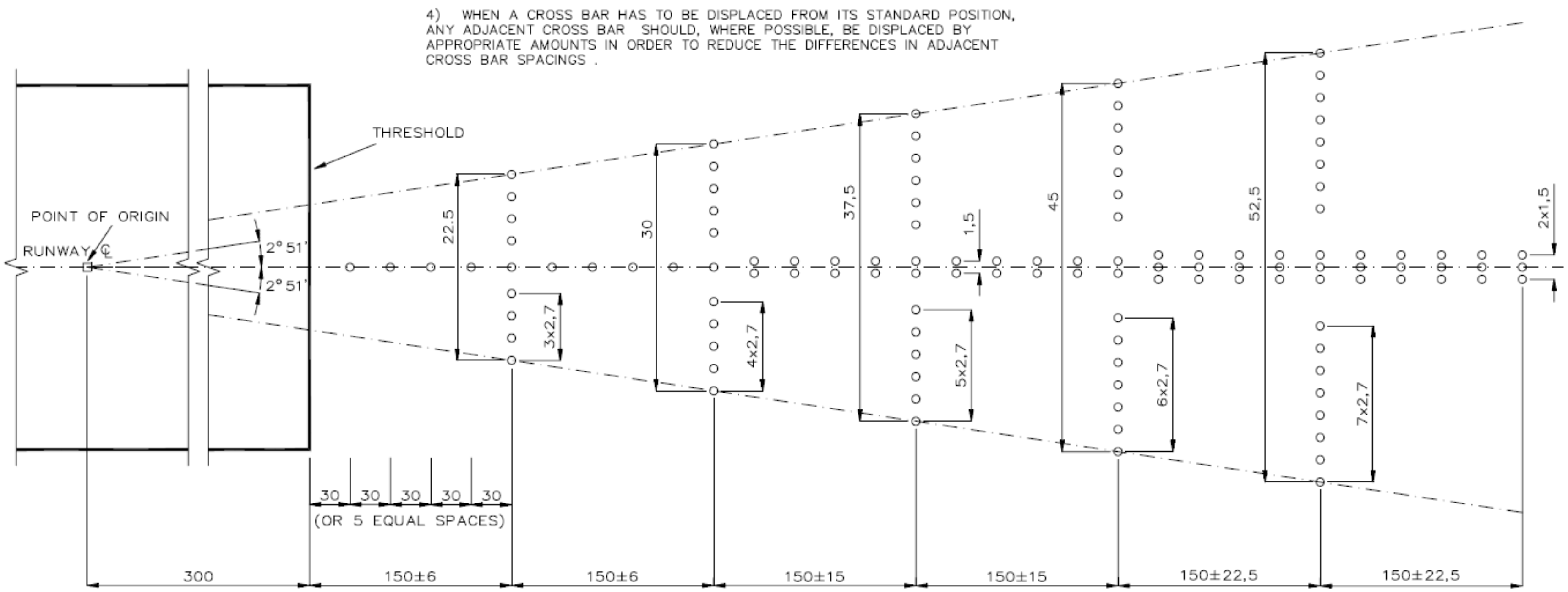


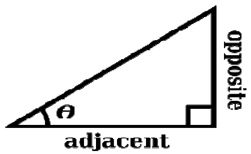
If the centre line consists of barrettes each
barrette
should be supplemented by a capacitor
discharge
light.

CAT I Precision Approach Lighting System (B type)



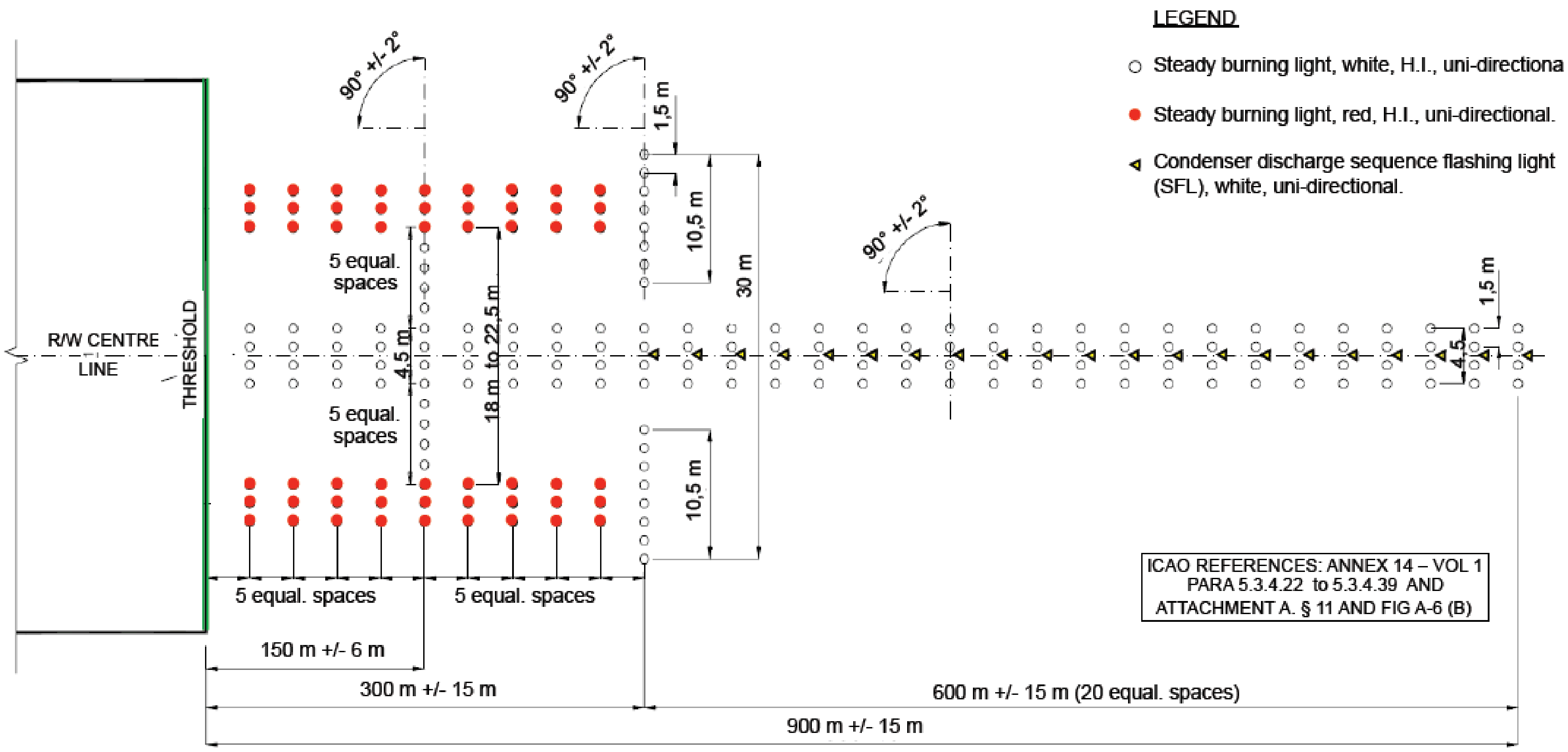
Distance Coded CAT I Precision Approach Lighting System (A type)
"CALVERT" System CAT I



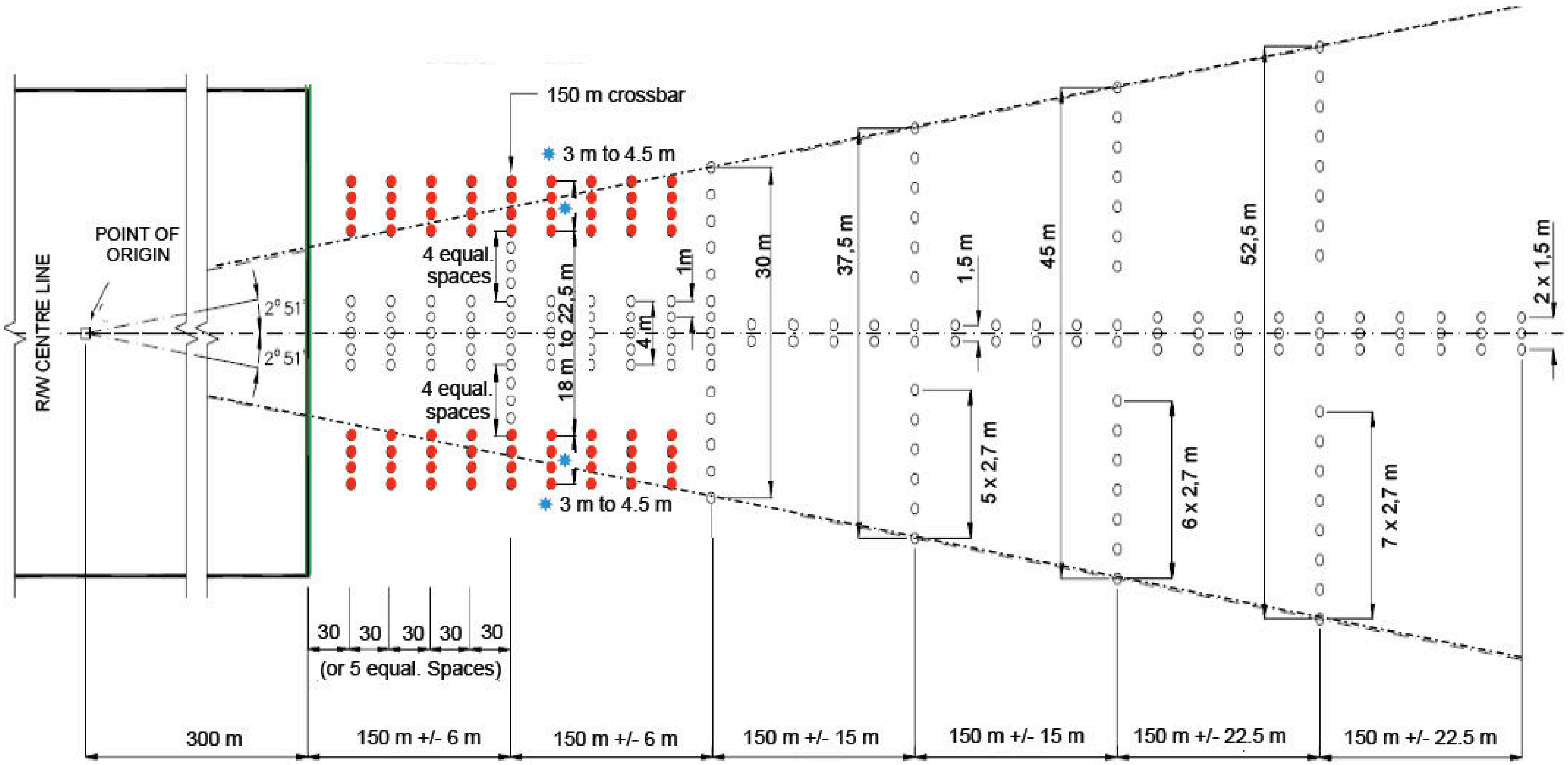


$$Tan\ \theta = \frac{\text{opposite}}{\text{adjacent}}$$

CAT II/III Precision Approach Lighting System (B type)(alsf-2)

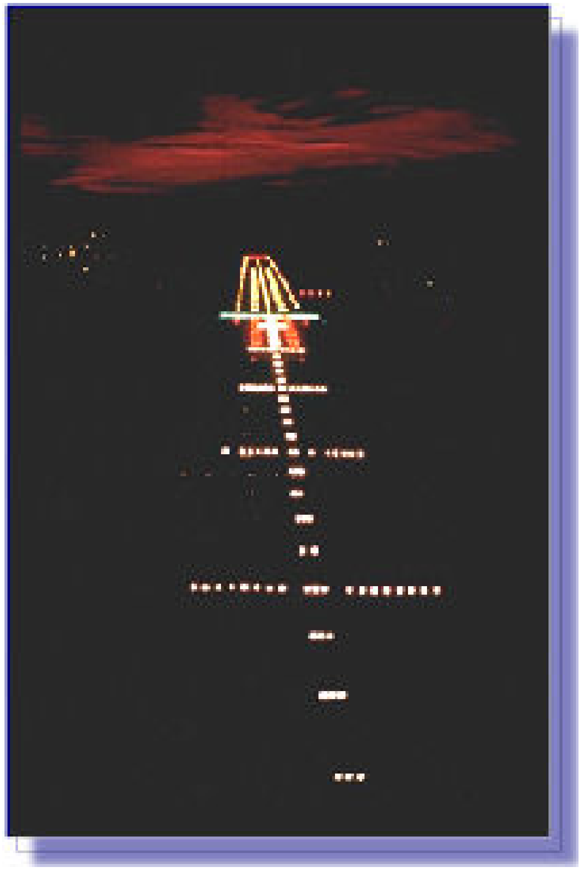


Distance Coded CAT II / III Precision Approach Lighting System (A type) "CALVERT" System CAT II/III



Precision Approach Lighting System type B and A

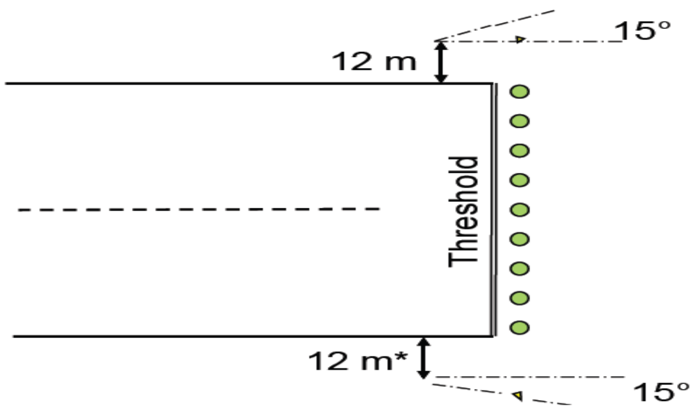
type B

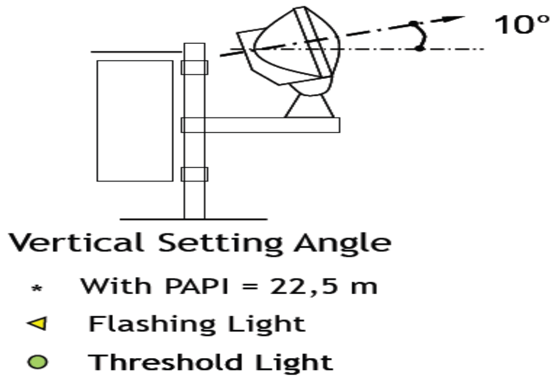


type A

Runway Threshold Identification Light Systems (RTILS)

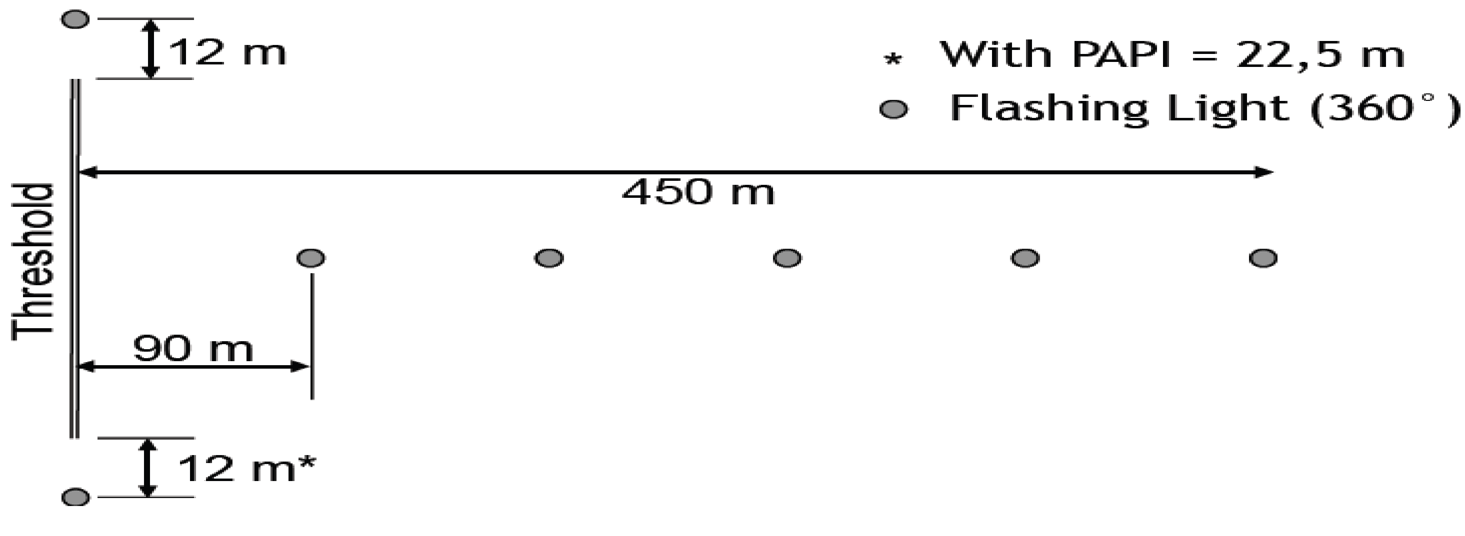
The threshold may have two additional capacitor discharge luminaires installed. The objective of these is to provide the pilot with information regarding the start of the runway.
The circuitry of the system is such that should one unit fail, then the other is prevented from operating.





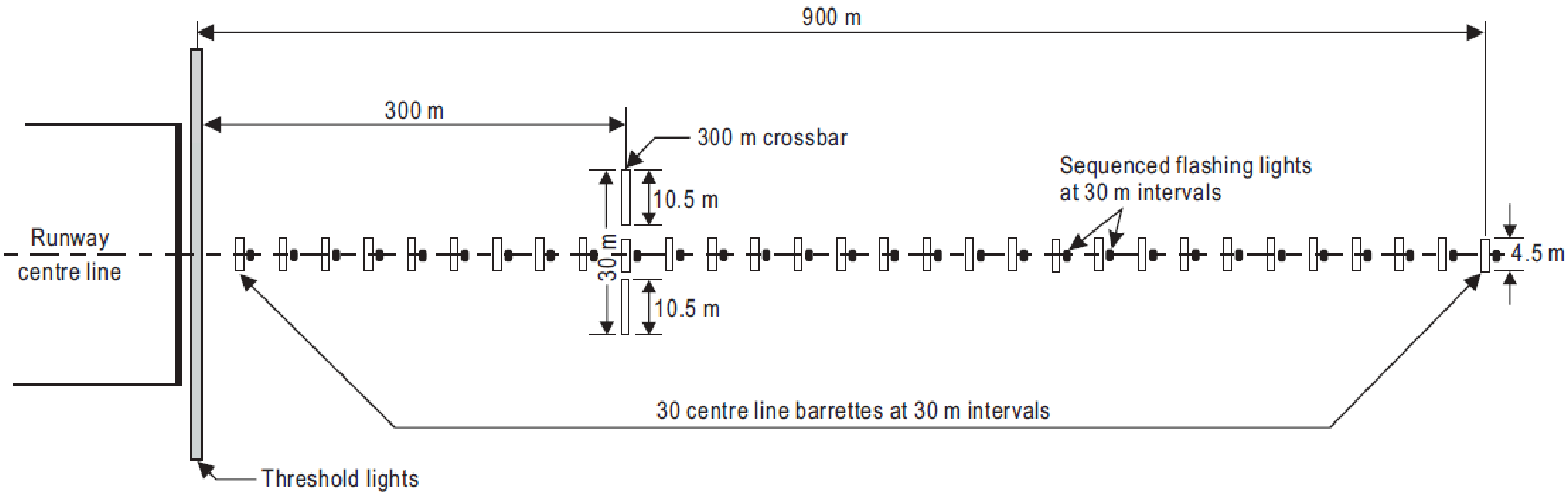
Omni---Directional Approach Lighting System (ODALS)

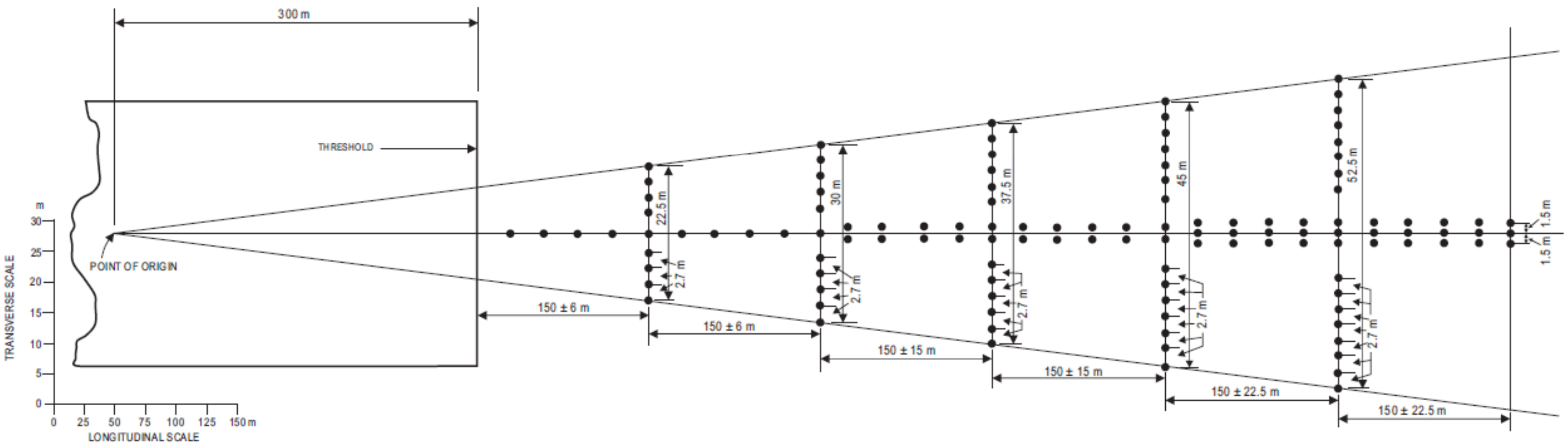
In an FAA specification capacitor discharge luminaires may be used to provide an alternative simple approach and circling guidance system. The system consists of seven omnidirectional strobe lights, five of them located on the extended centre line and the other two at the runway threshold as shown.



Approach & Runway Lights

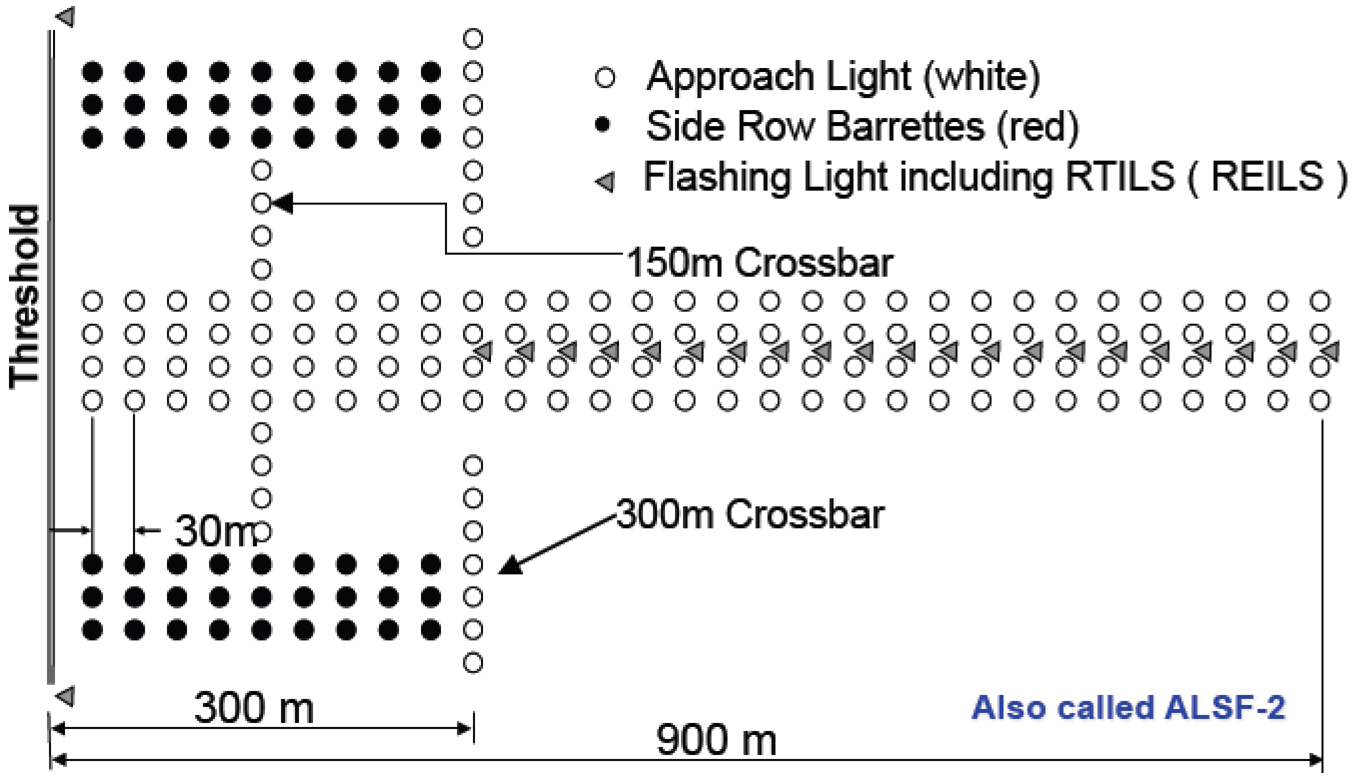
Precision approach category I lighting system





A — DISTANCE CODED CENTRE LINE

Typical Lighting pattern ICAO Approach --- Category II/III (Barrette)



Visual approach slope indicator systems

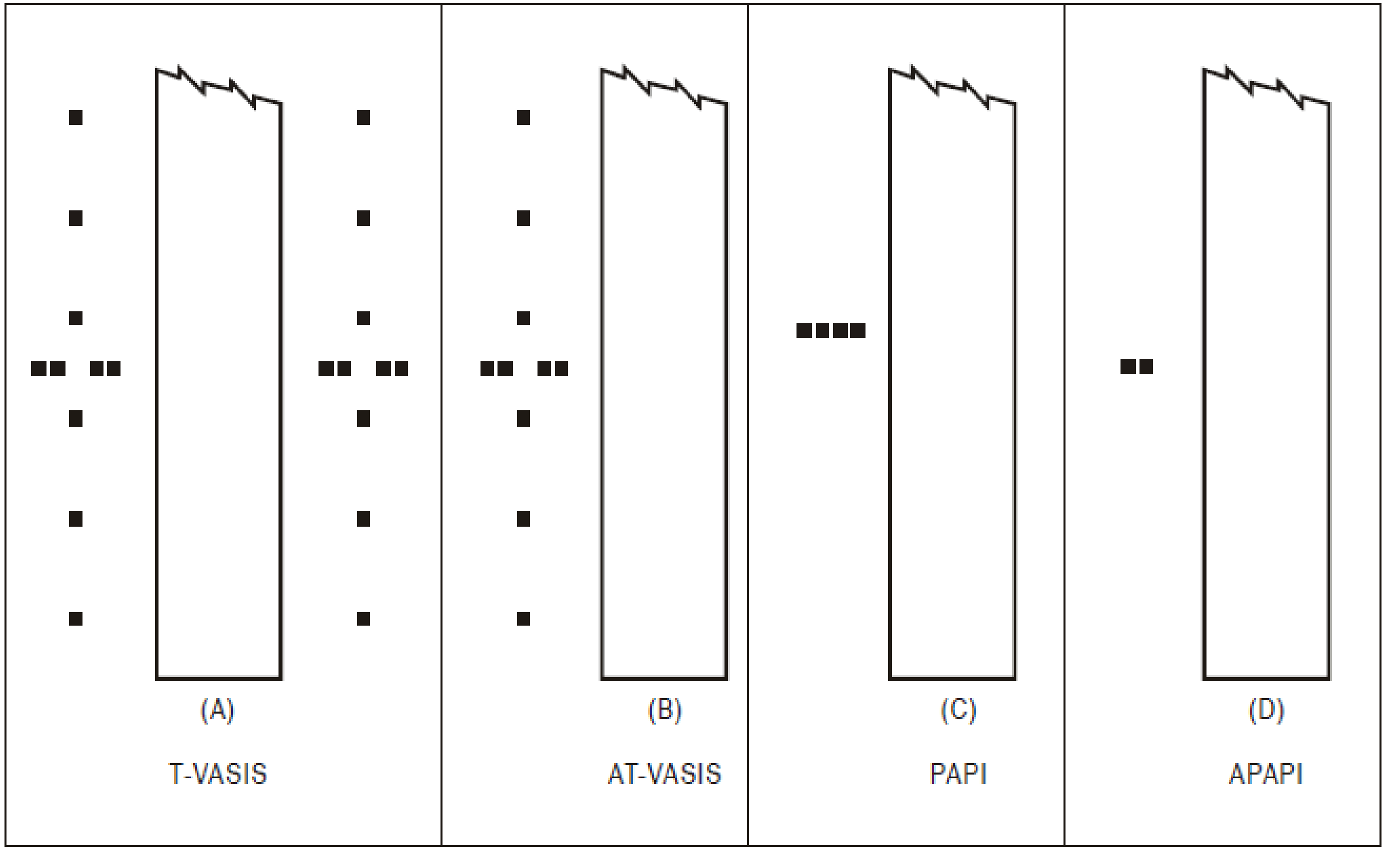
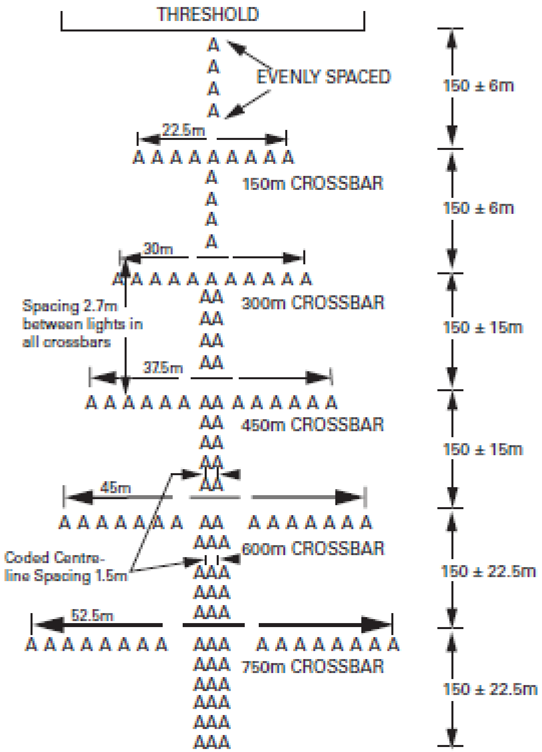
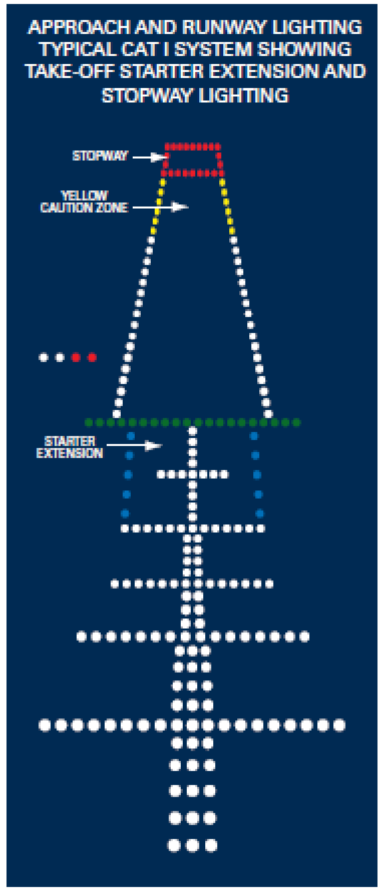


Figure 5-16. Visual approach slope indicator systems

Typical Lighting Pattern Precision Approach Category I (CAT I)

The pattern is called :
- Distance Coded
- Calvert
- CL5B
- Type A

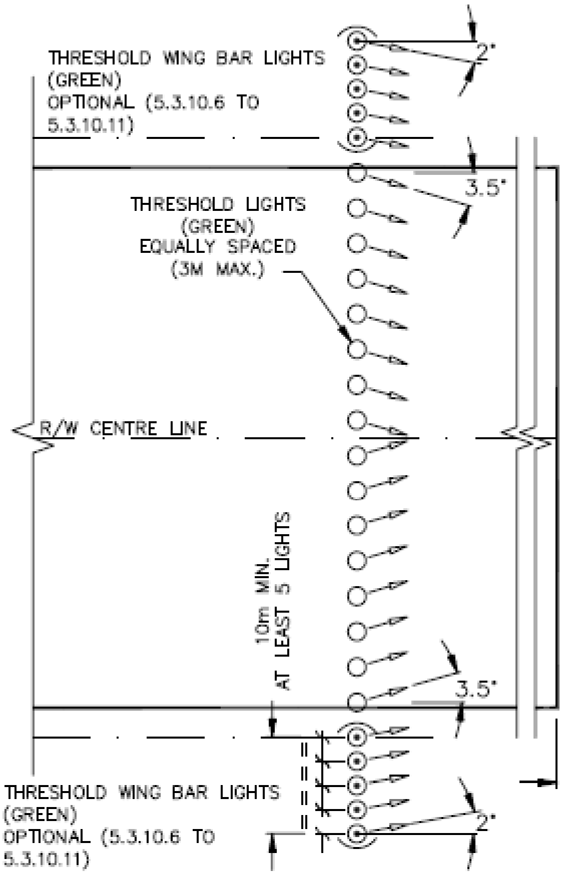


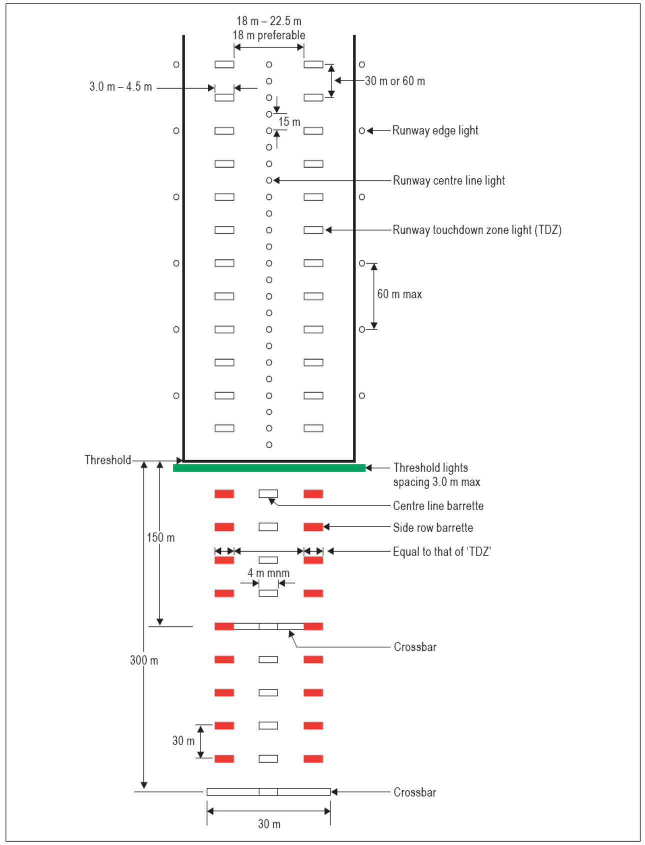


Threshold Lights

Threshold Wing Bar Lights

Details of Threshold Wing Bar Lights





Threshold WingBars may be provided consisting of two rows of 5 lights forming a row of lights (length of each row to be 10m max ie. 2.5m light spacing) and each row of WingBar lights shall be located either side of the threshold with the first light aligning with the row of runway edge lights

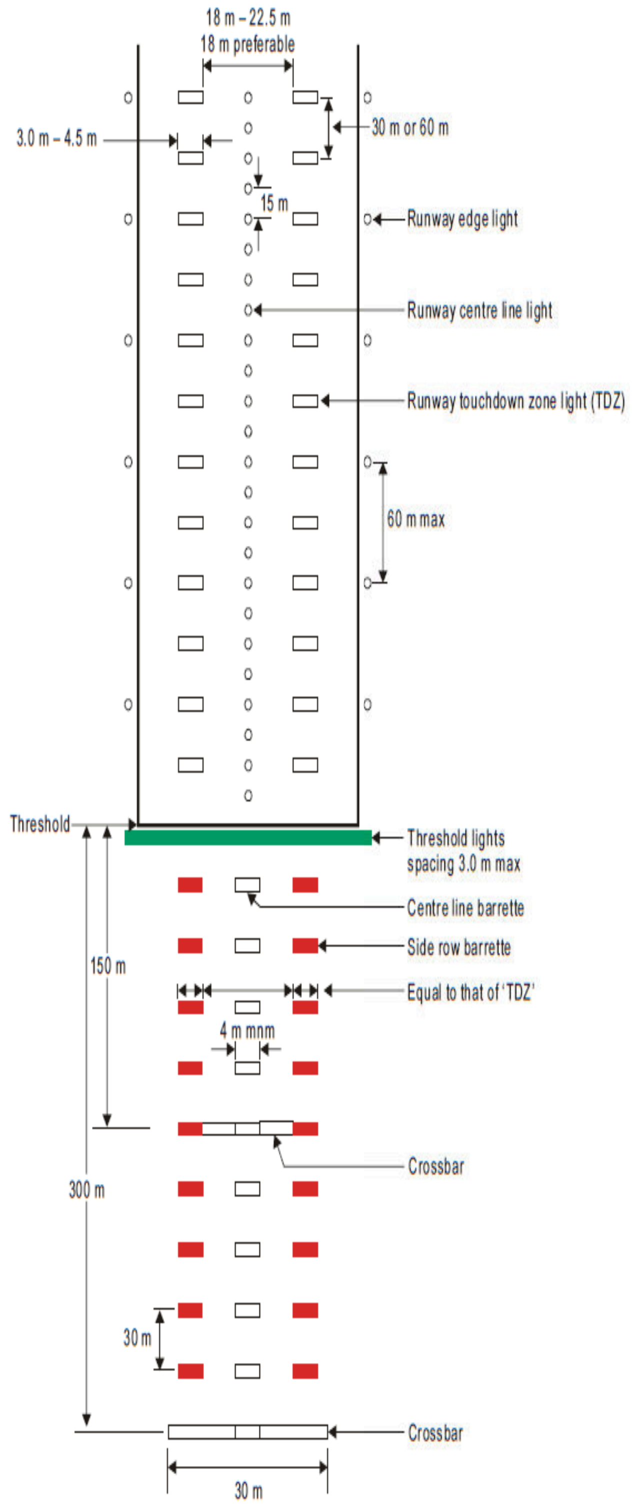
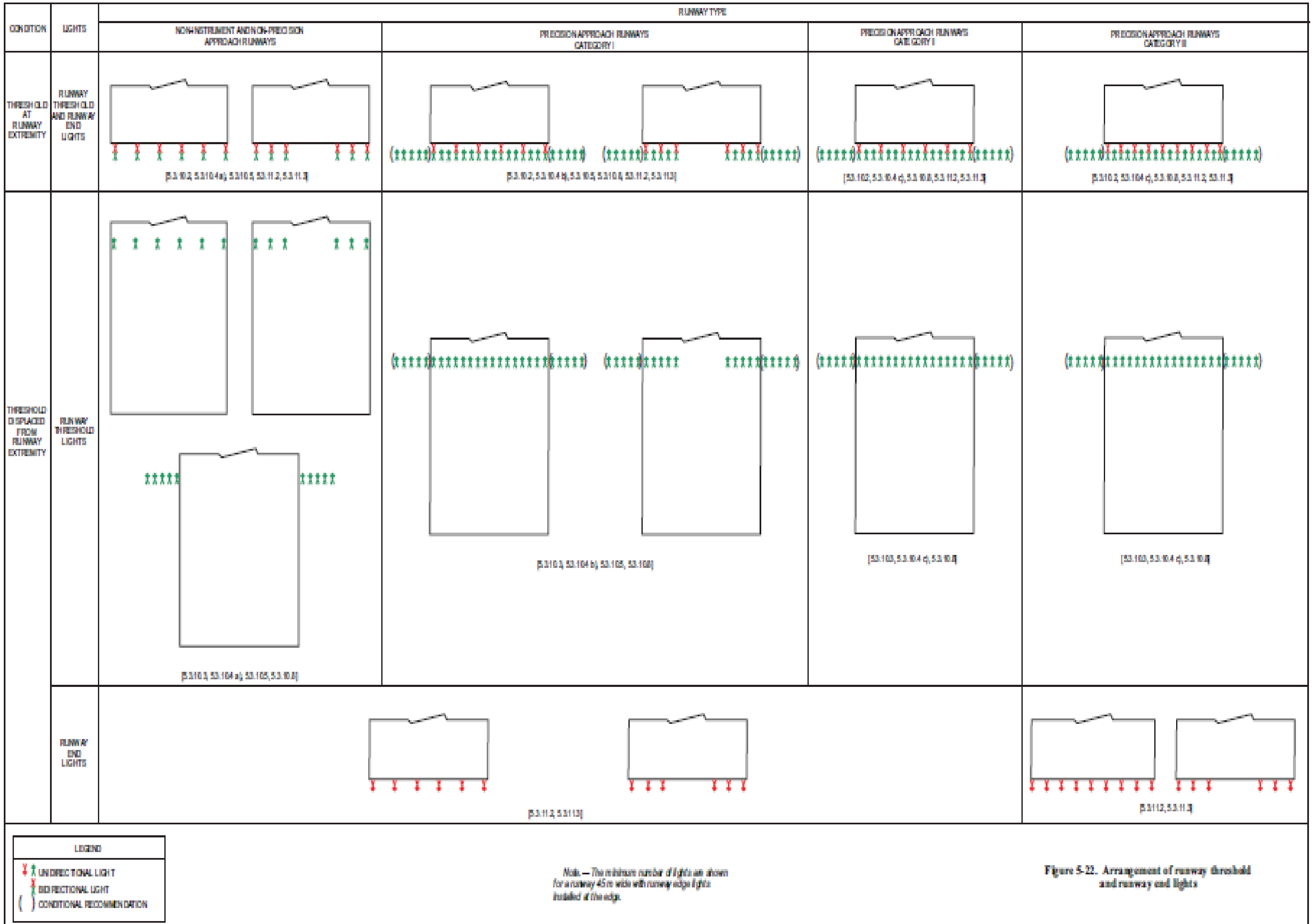


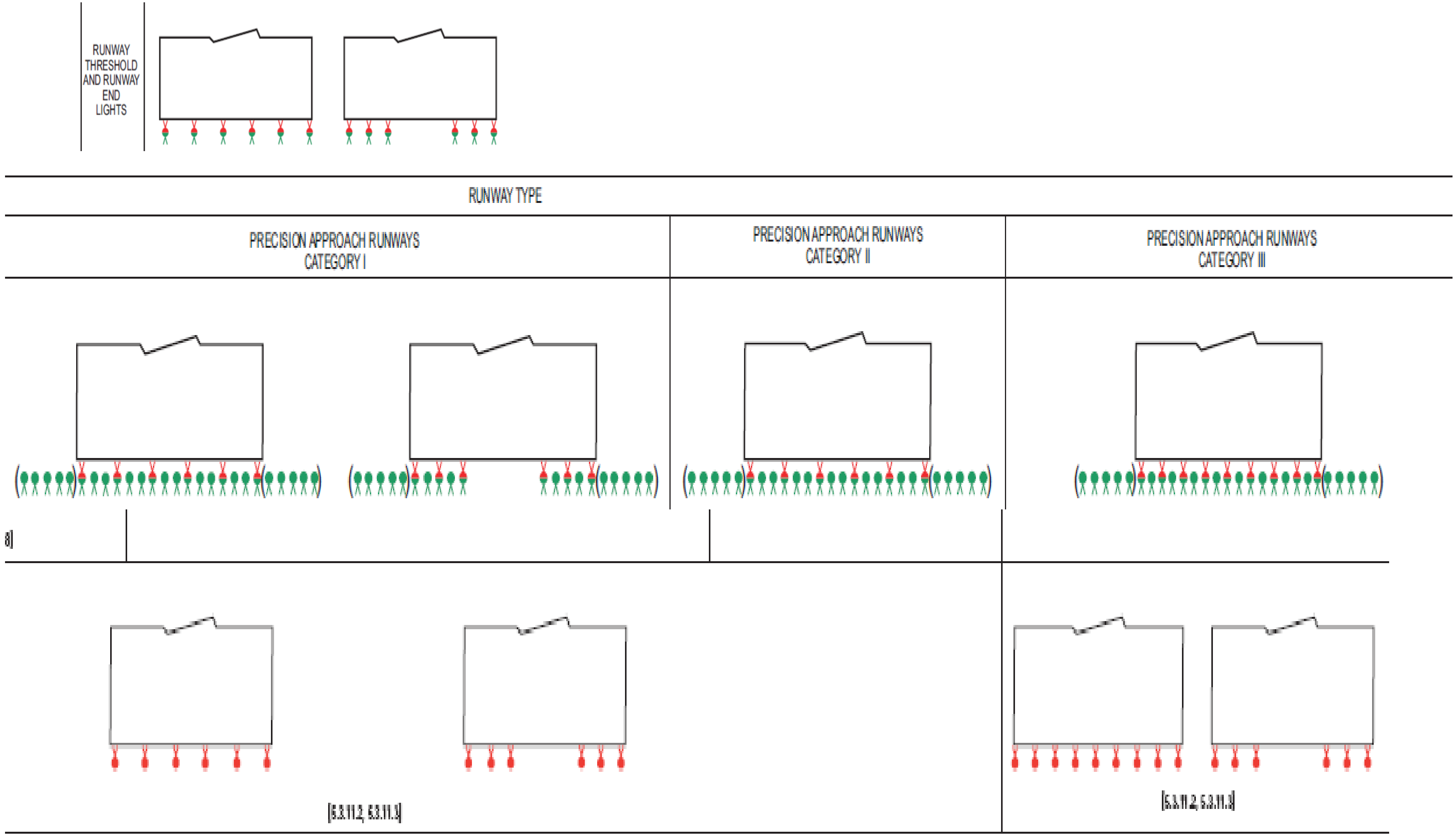
Figure 5-14. Inner 300 m approach and runway lighting for precision approach runways, categories II and III



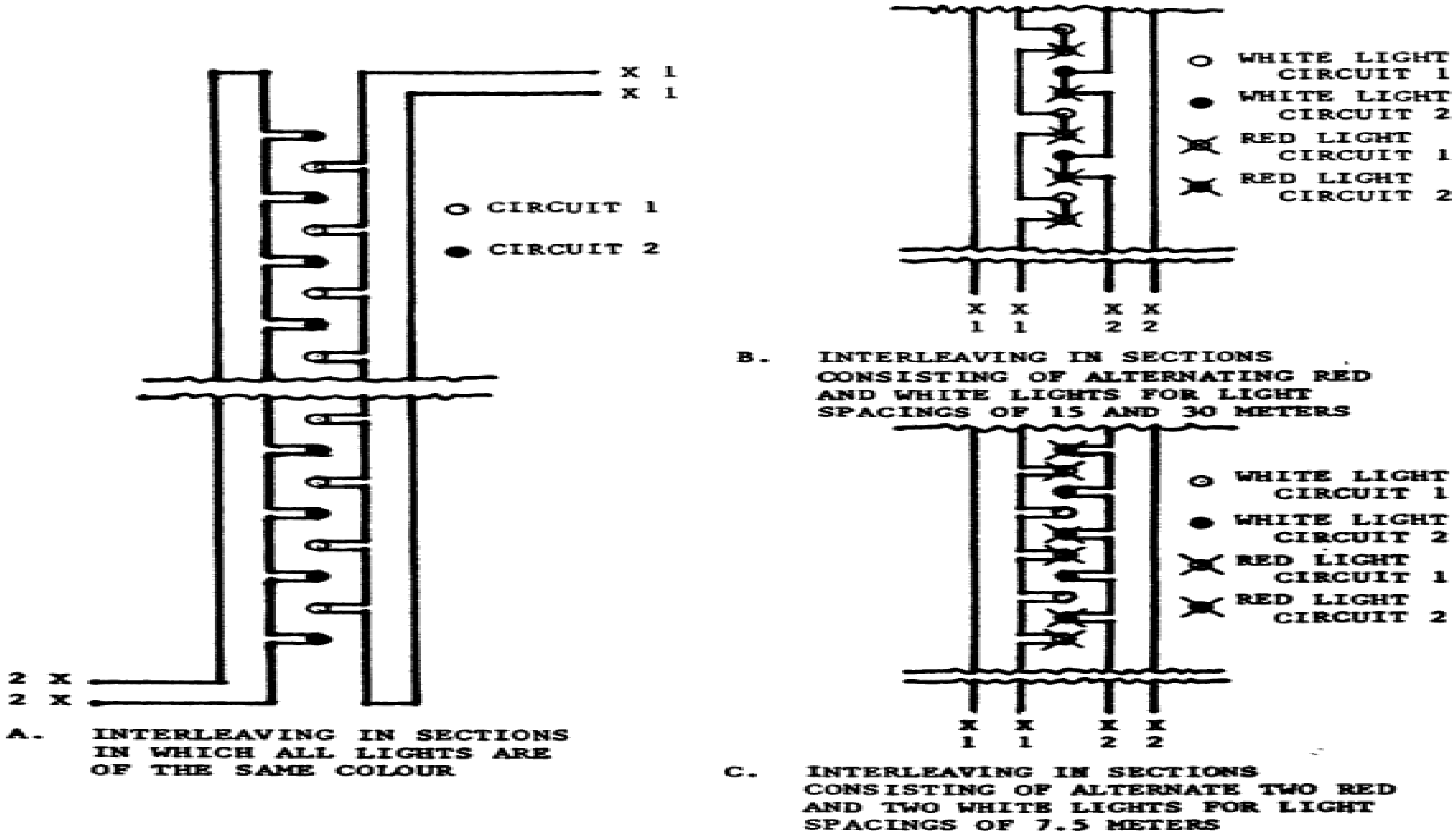
Note.— The minimum number of lights are shown for a runway 45 m wide with runway edge lights installed at the edge.

Figure 5-22. Arrangement of runway threshold and runway end lights

Runway End Lights --- additional information

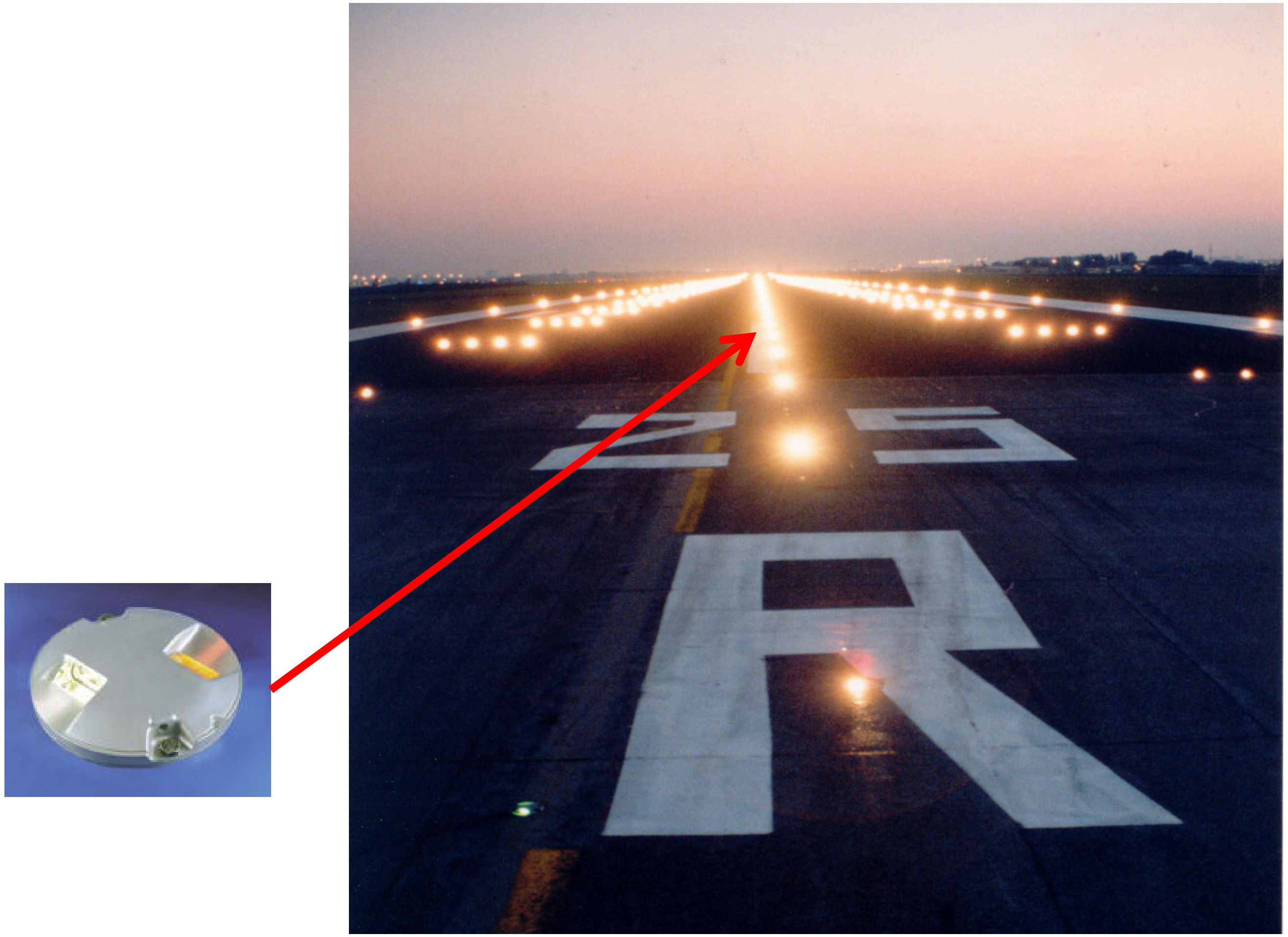


Runway Centreline lights



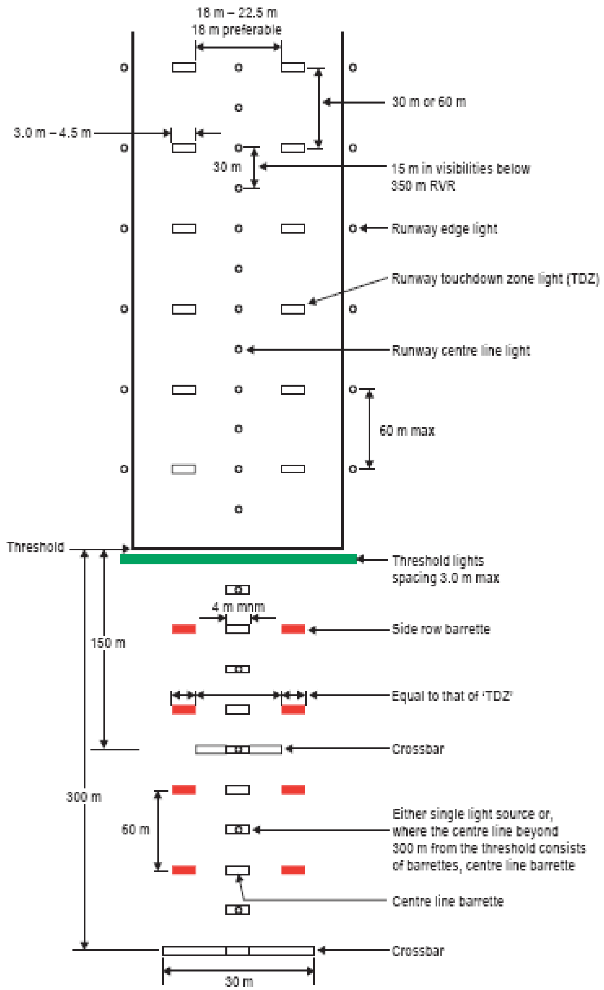
Runway centre line lighting on two interleaved series circuits

Runway Centreline lights

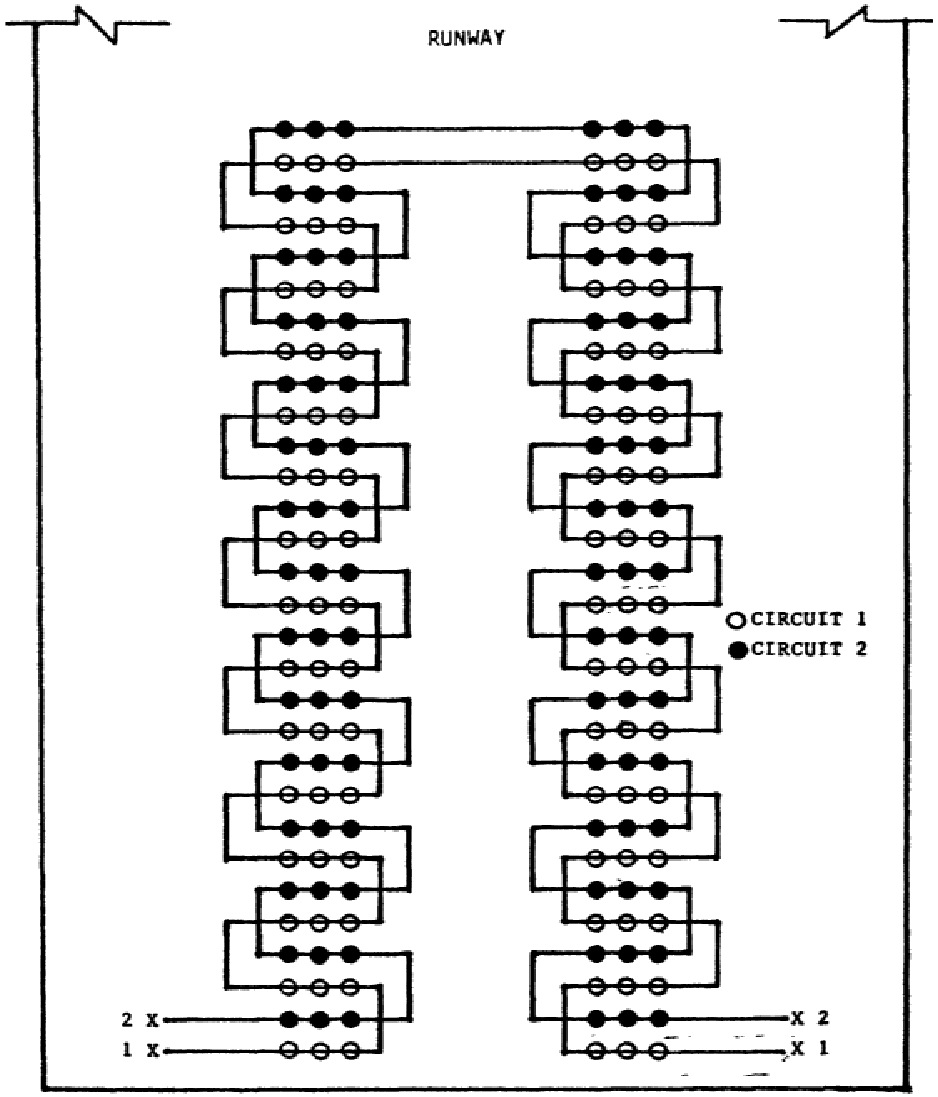


TDZ : Spacing can be different if you can guarantee that Maintenance Targets can be met with respect to serviceability

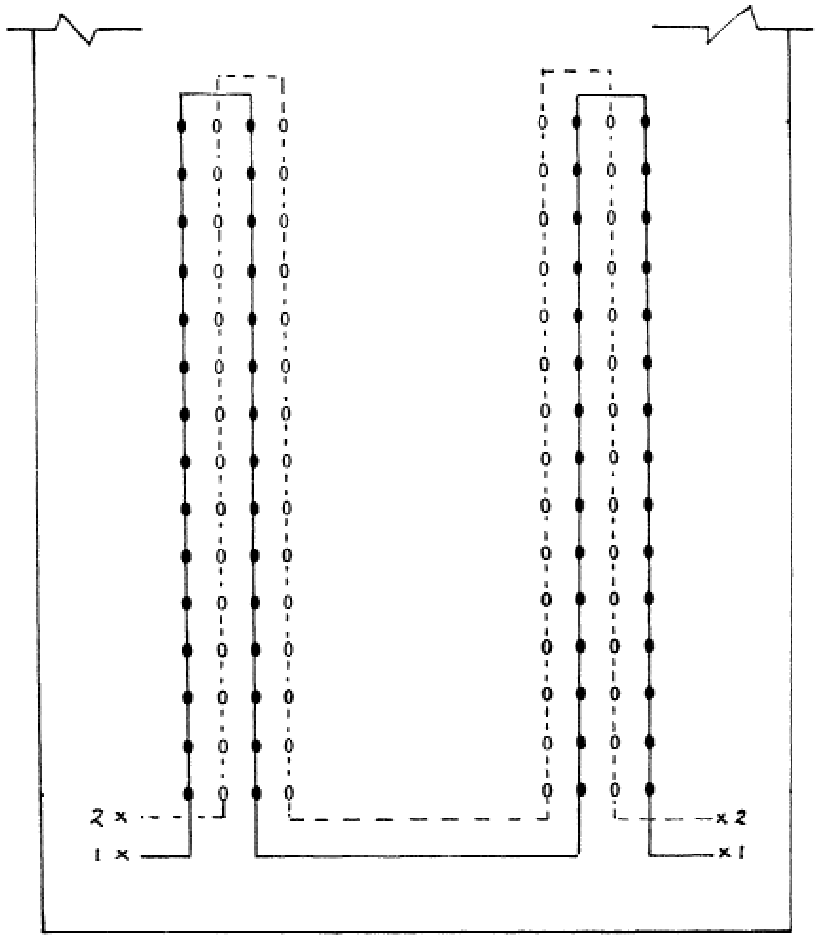
((Spacing 30m or 60 m)



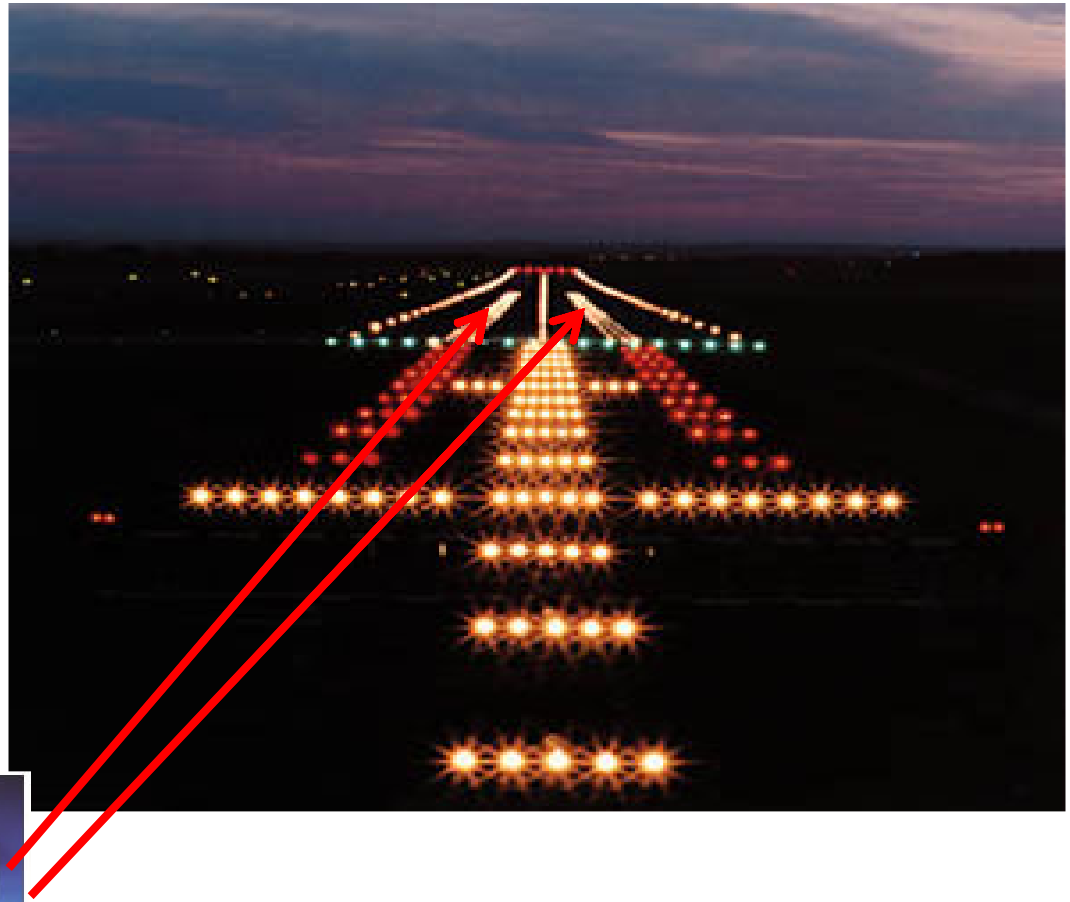
Touchdown Zone Lighting on two interleaved series circuits (ICAO Barrette)



Touchdown Zone Lighting on two interleaved series circuits (ICAO Barrette)

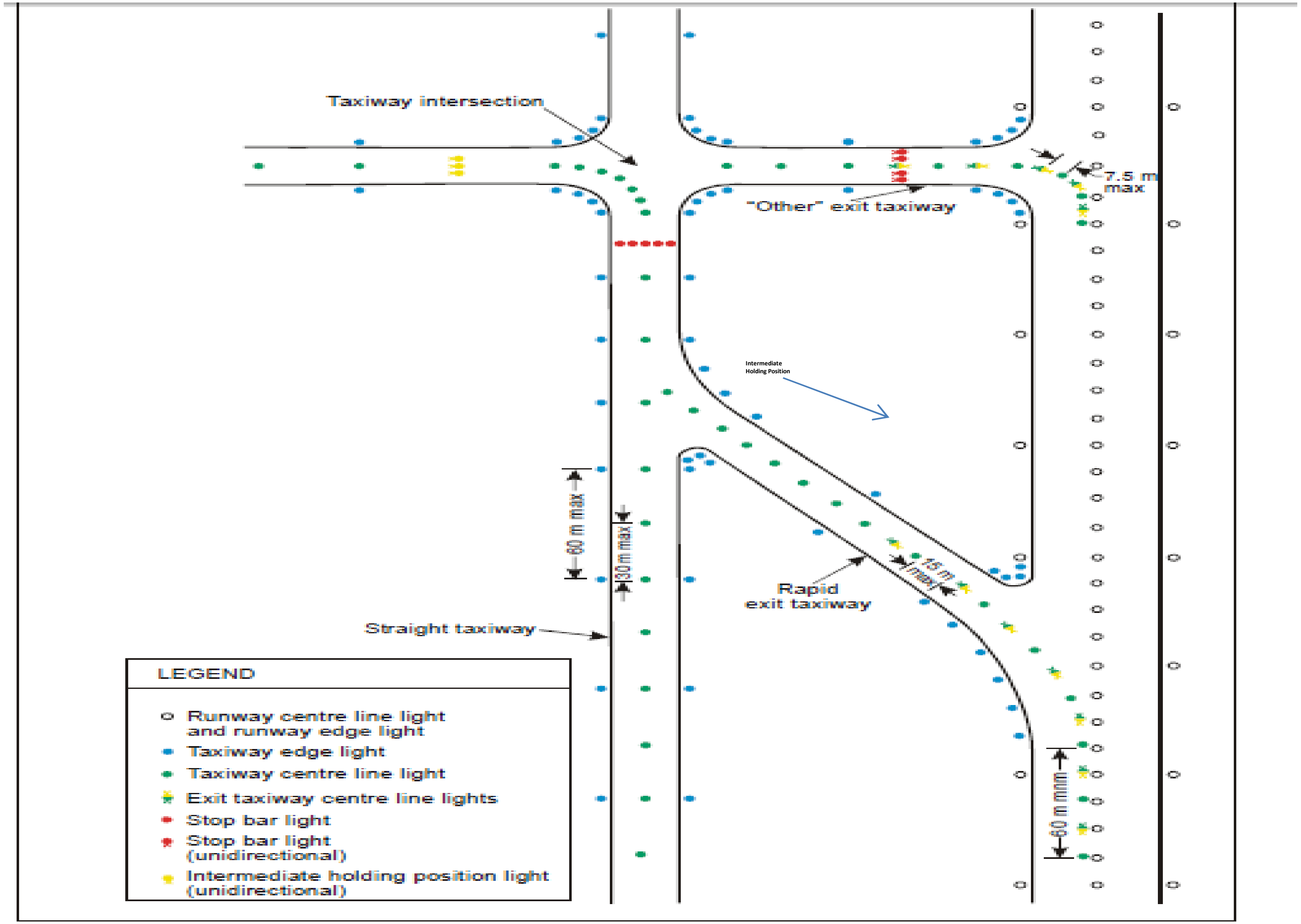


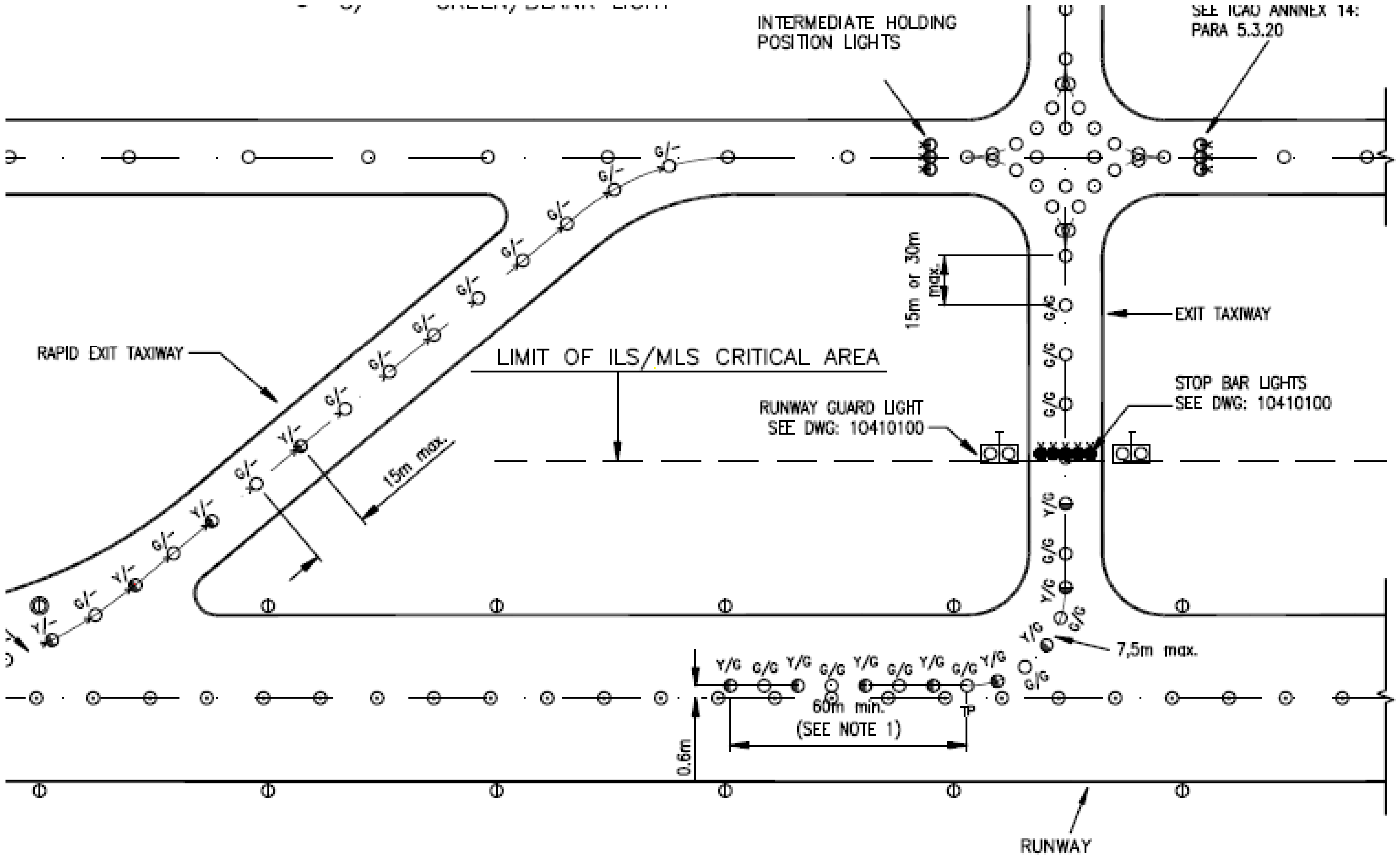
Runway Touch Down Zone Lights (TDZ)



Threshold Lights

Typical Taxiway network showing Taxiway related Lights





INTERMEDIATE HOLDING POSITION LIGHTS
SEE ICAO ANNNEX 14: PARA 5.3.20
15m or 30m max.
EXIT TAXIWAY
RAPID EXIT TAXIWAY
LIMIT OF ILS/MLS CRITICAL AREA
STOP BAR LIGHTS SEE DWG: 10410100
RUNWAY GUARD LIGHT SEE DWG: 10410100
15m max.
7,5m max.
60m min. (SEE NOTE 1)
TP
0.6m
RUNWAY

Typical Insulation Resistance Values we could expect to see !

Length of circuit :

- 1500 meters -- 50 Megohms
- 2000 meters --- 45 Megohms
- 3000 meters --- 35 Megohms
- 4500 meters --- 30 Megohms
- 6000 meters --- 25 Megohms

However, remember must calculate the actual values in accordance with ICAO AND Also in accordance with your "national" requirements for insulation levels !

Measurement of Insulation Resistance of Primary cable & Set-- up for CCR Earth Fault Detection

Maximum insulation leakage current based on the ICAO Design Manual Part 5 §3.9.4.7

- **1µ A** Allowed for each series transformer
- **2µ A** Allowed for each 100 meters of primary cable (this value includes for the normal number of connectors and splices)

Take for example a Runway centre-line circuit containing 133 light fixtures

- Maximum allowable leakage for transformers = 2 × **133 = 266 µ A**
-
- If length of the circuit is 10 KM then maximum leakage for cable = **1000/100 =100 µ A**
- Total allowable leakage for circuit @ 266 + 100 = **366 µ A**

Set---up for Earth Fault Detector (EFD)

The design value for the cable & connectors is 5000V (5kV

Therefore when testing with Megger set to 5000 V range then the resistance R must be :

R = V/I Therefore R = 5000 volts **ohms** 366 Micro-amps >>5000/366= 13.7 MΩ

For the EFD alarm by the CCR :

The recommended alarm levels are:

level 1 = 2 X calculated value = 2 X 13.7 = 27.4 mega ohms

level 2 = 0.5 X calculated value = 0.5 X 13.7 = 6.8 mega ohms

If the calculated value = is above 150 meg-ohms then there is no need to multiply by 2 for the level 1 alarm

- **AFL/ AGL Fault Finding**

Two principal fault conditions :

- **Short Circuit (this has normally been created by earths in the system .....**

eg.

--- single earth

---two or more earths

- **Open Circuit**

Short circuit:

Some of the lights in a circuit will go out Q Some f the lights in a circuit will go dim

- ***Open circuit :***

All the lights will go out

the CCR will shut own

Elevated lights

Elevated runway, stop ways and taxiway lights shall be frangible. Their height shall be sufficiently low to preserve clearance for propellers and for the engine pods of jet aircraft

Surface lights

Light fixtures inset in the surface of runways, stop ways, taxiways and aprons shall be so designed and fitted as to withstand being run over by the wheels of an aircraft without damage either to the aircraft or to the lights themselves.

Light intensity and control

In dusk or poor visibility conditions by day, lighting can be more effective than marking

Where a high-intensity lighting system is provided, a suitable intensity control shall be incorporated to allow for adjustment of the light intensity to meet the prevailing conditions.

— approach lighting system;

— runway edge lights;

— runway threshold lights;

— runway end lights;

— runway centre line lights;

— runway touchdown zone lights; and

— taxiway centre line lights.

Circuit Checks

- **Continuity Checks:**

Checking the resistance value of the series circuit

--- This checks the condition or integrity of the loop

resistance values will be relatively low

eg. 20---30 ohms range dependant the size of circuit

regular checking & recording of this value will give an indication of the normal value.

Changes then can be observed.

Insulation Resistance Checks :

- this checks for leakages To earth
- can be checked manually or with the facility provided in the CCR. Manually --- we use an Insulation Tester

generally referred to as a Megger

Summary of Lighting Sources principally between Tungsten Halogen & LED

-Visible part of the AGL

-Fitting + corresponding Mounting System

-Two types of fittings:

-Inset Lights (for every locations where a plane is likely to roll on)

-Elevated (for any other location).

Four types of light source:

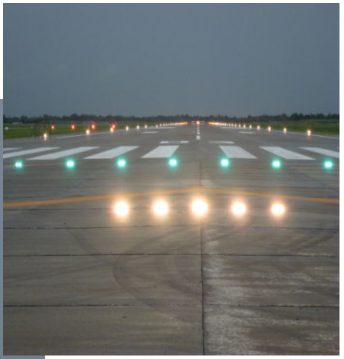
-Incandescent (max 500h @ full intensity)

-Halogen (max 1500h @ full intensity)

-Fluorescent (max 8000h @ full intensity)

-LED (max 100,000h @ full intensity)

Threshold Lights



Runway threshold identification lights

should be installed:

- *at the threshold of a non-precision approach runway when additional threshold conspicuity is necessary or where it is not practicable to provide other approach lighting aids*
- *where a runway threshold is permanently displaced from the runway extremity or temporarily displaced from the normal position and additional threshold conspicuity is necessary.*

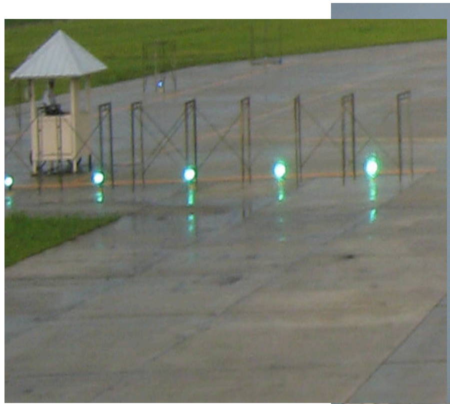
Location

Runway threshold identification lights shall be located symmetrically about the runway centre line, in line with the threshold and approximately 10 m outside each line of runway edge lights.

Characteristics

- **Recommendation.—** ***Runway threshold identification lights should be flashing white lights with a flash*** *frequency between 60 and 120 per minute.*
- The lights shall be visible only in the direction of approach to the runway.

Threshold Wing Bar Lights



ICAO (International Civil Aviation Organisation)

Annex 14 Volume 1 --- Aerodromes
Annex 14 Volume 2 --- Heliports Aerodrome Design
Manual Part 4 --- Visual Aids
Aerodrome Design Manual Part 5 --- Electrical systems
Aerodrome Design Manual Part 6 --- Frangibility
Airport Services Manual Part 9 -- Airport Maintenance Practices

IEC International Electrotechnical Commission)

Technical Specification (TS) 61821 --- IEC EN (European Norm)

Electrical installations for lighting and beaconing of aerodromes --- Maintenance of aeronautical ground lighting constant current series circuits