A SunCam online continuing education course

Airport Engineering

Part IV: Lighting & NAVAIDs

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Introduction

This course focuses on airport lighting and navigation aids (NAVAIDs). Numerous visual and navigation aids are used to provide information and guidance to pilots. They may be single units or complex systems composed of many parts. The document that follows addresses the basic features and layouts of said topics. In-depth design requirements and installation procedures are not covered.

Airport Lighting

Airport lighting systems are commonly observed at airports. Lights are critical features that aid airborne and taxiing pilots alike.

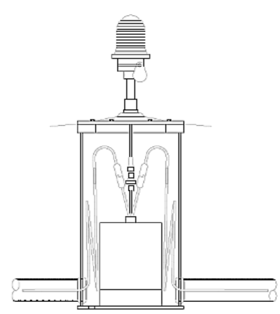
A specific topic regarding airport lighting is worth noting as a general topic. Light emitting diodes (LED) have been used in an increasing fashion. Issues arise when LEDs are interspersed with incandescent lights as may cause distortion or perceived difference in color and brightness. Therefore, LED and incandescent lights must not be mixed.

Runway & Taxiway Edge Lights

Edge lighting systems are used to outline usable operational areas of airports during periods of darkness (i.e. night) and low visibility weather conditions. These systems are classified according to the intensity produced by the lighting system.

There are four categories of edge lights:

- Low Intensity Runway Lights (LIRL)
  - Install on visual runways at small airports
- Medium Intensity Runway Lights (MIRL)
  - Install on visual or non-precision instrument runways
- High Intensity Runway Lights (HIRL)
  - Install on precision instrument runways
- Medium Intensity Taxiway Lights (MITL)
  - Install on taxiways and aprons at airports where runway lights are installed

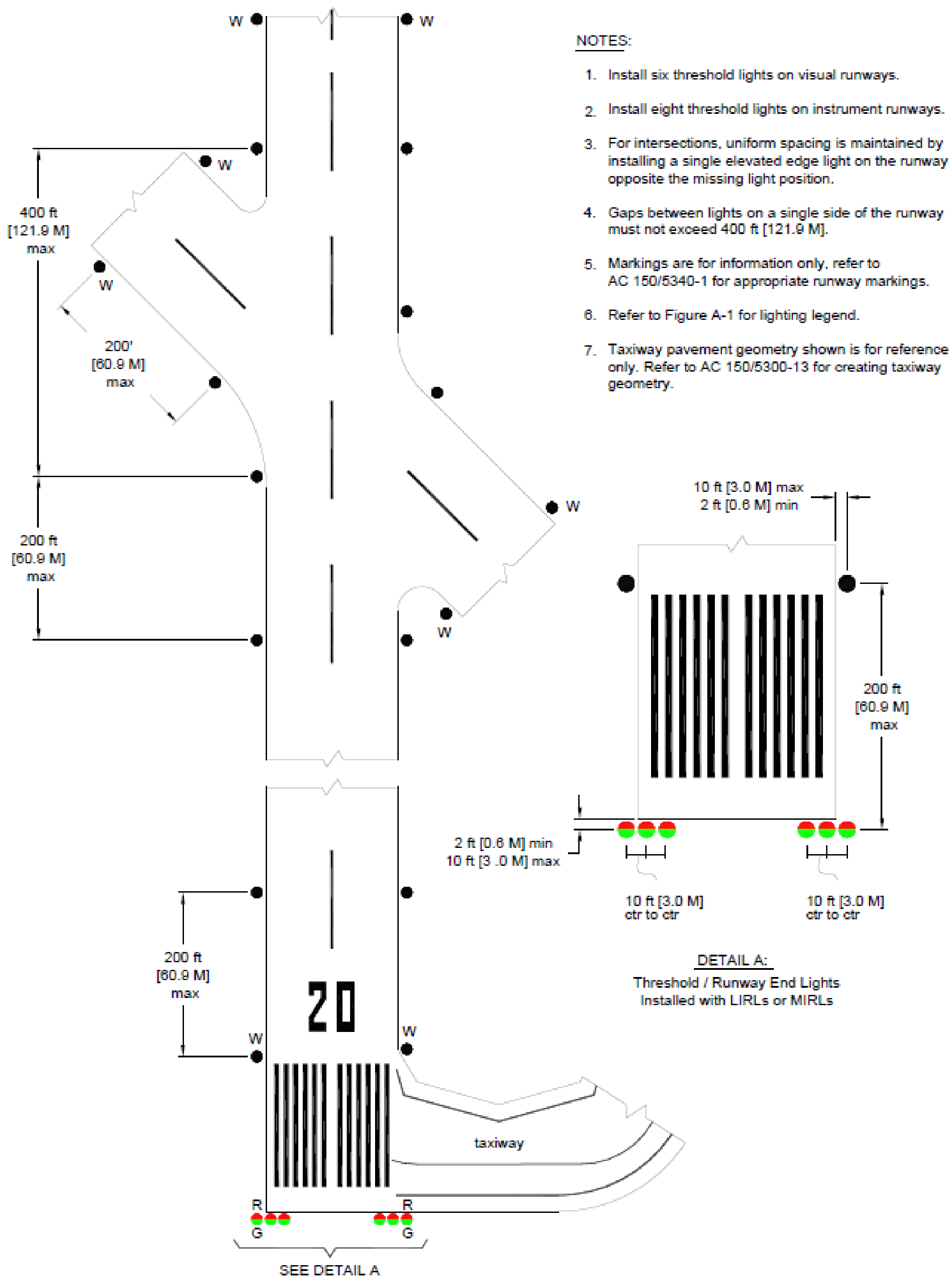


Runway and edge light configurations can be complex. Sample visual demonstrations from AC 150/5340-30J follow; see advisory circular for further details.

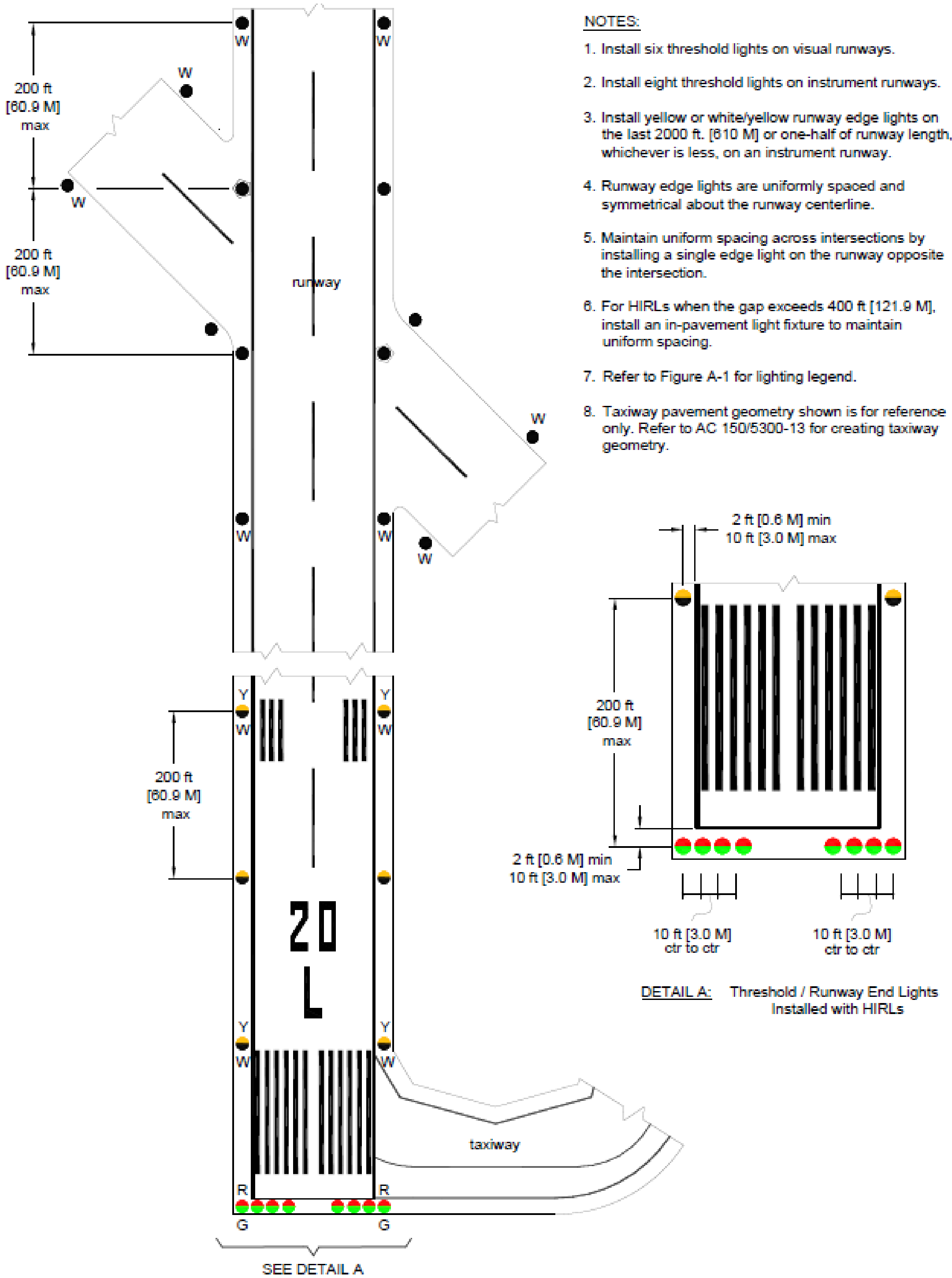
Runway & Taxiway Lights

EDGE LIGHTING COLOR CODE:

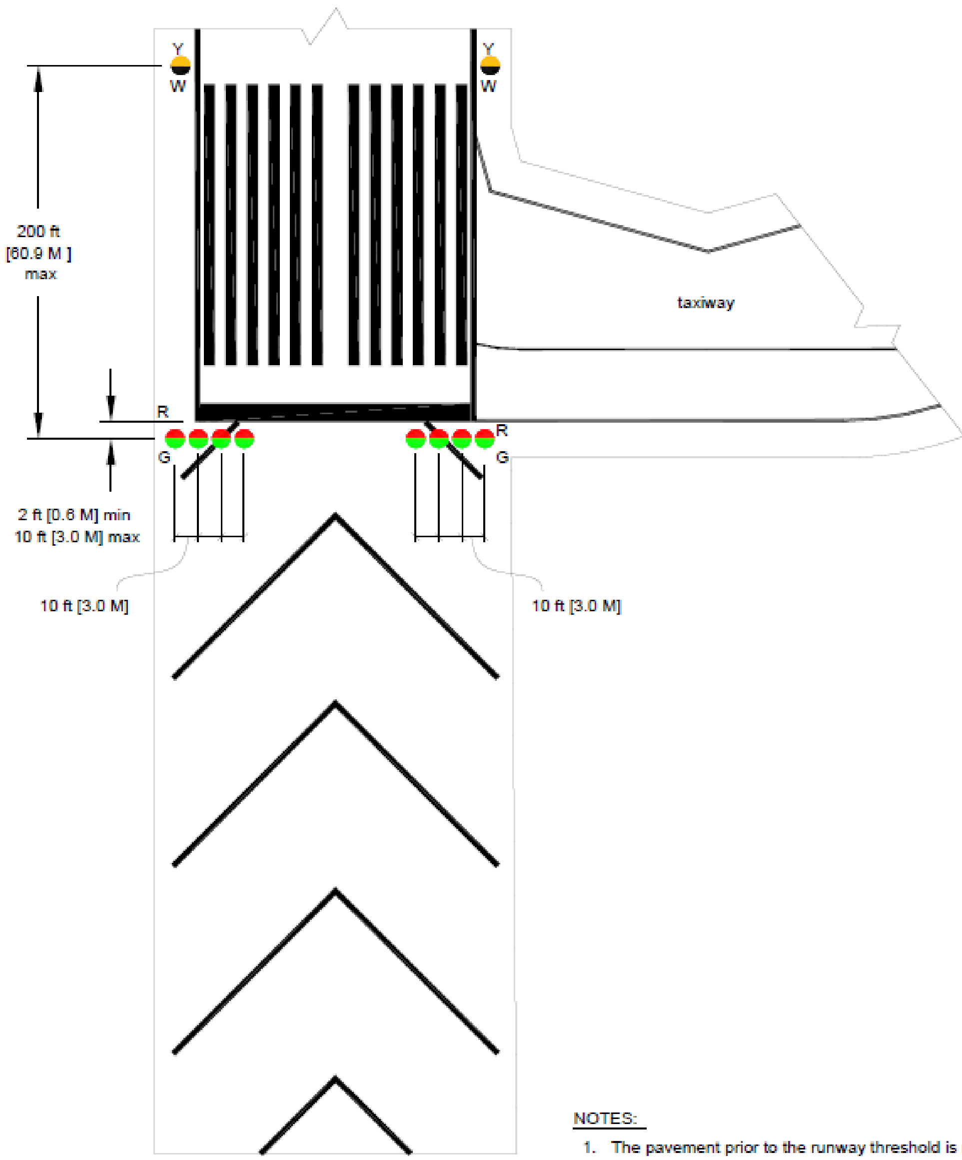
G / R	Runway Threshold / End Lights Green (G) / Red (R)
Y W	Runway Edge Lights (See note 3) Yellow (Y) / White (W)
W	Runway Edge Light White (W)
W	Runway Edge Light (In-pavement) White (W)
R	Runway Threshold / End Light Red (R)
B	Taxiway Edge Light Blue (B)
Y R	Runway Edge Light at Displaced Threshold Yellow (Y) / Red (R)
G Y	Threshold / Runway Edge Lights at Displaced Threshold Green (G) / Yellow (Y)
G UNI	Runway Threshold Light with a Uni-Directional Green (G UNI)
W R	Runway Centerline, Land and Hold Short Operations (LAHSO) White (W) / Red (R)



Runway and Threshold Lighting Configuration (LIRL Runways and MIRL Visual Runways)



Runway and Threshold Lighting Configuration (HIRL Precision Instrument Approach - Runway Centerline Not Shown for HIRL. Non-Precision Instrument Approach for MIRL)



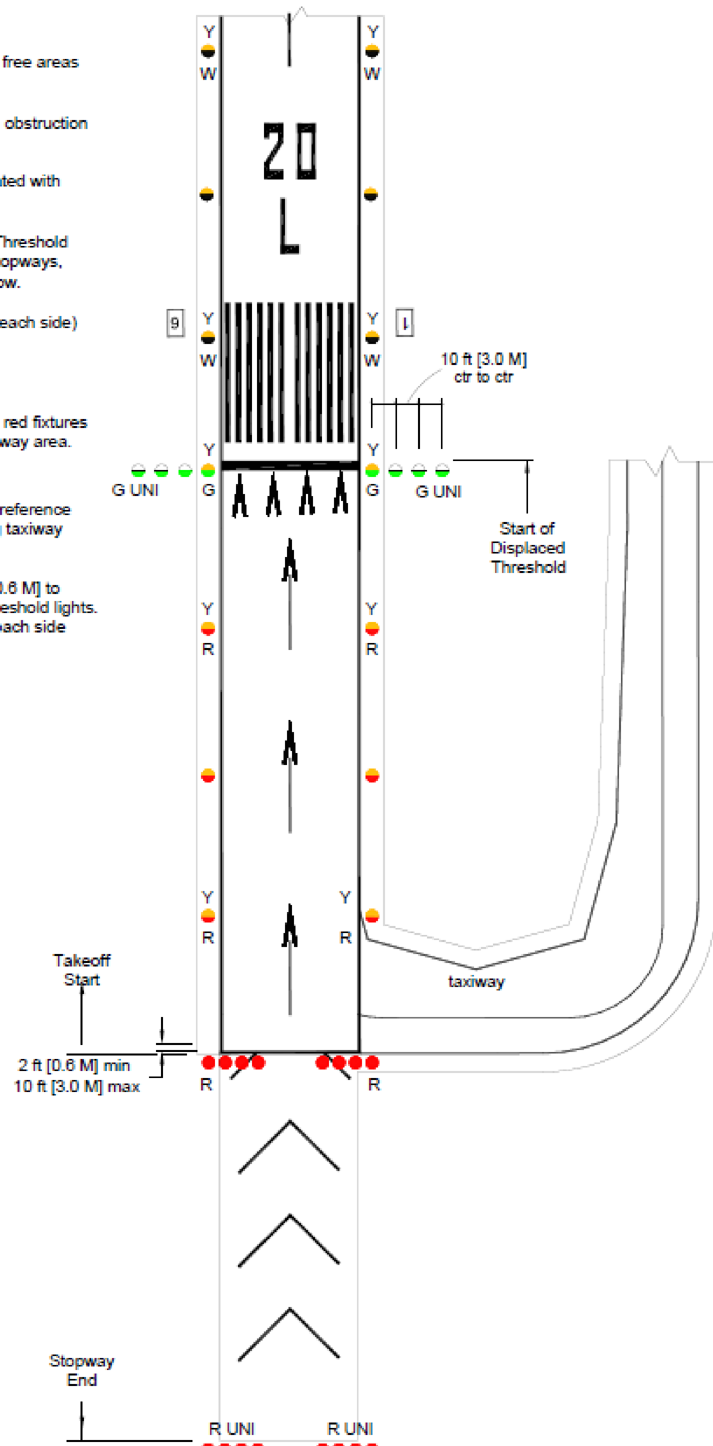
NOTES:

1. The pavement prior to the runway threshold is not for aircraft use.
2. Install six threshold lights on visual runways.
3. Install eight threshold lights on instrument runways.
4. Refer to Figure A-1 for lighting legend.
5. Taxiway pavement geometry shown is for reference only. Refer to AC 150/5300-13 for creating taxiway geometry.

Runway with Blast Pad

NOTES:

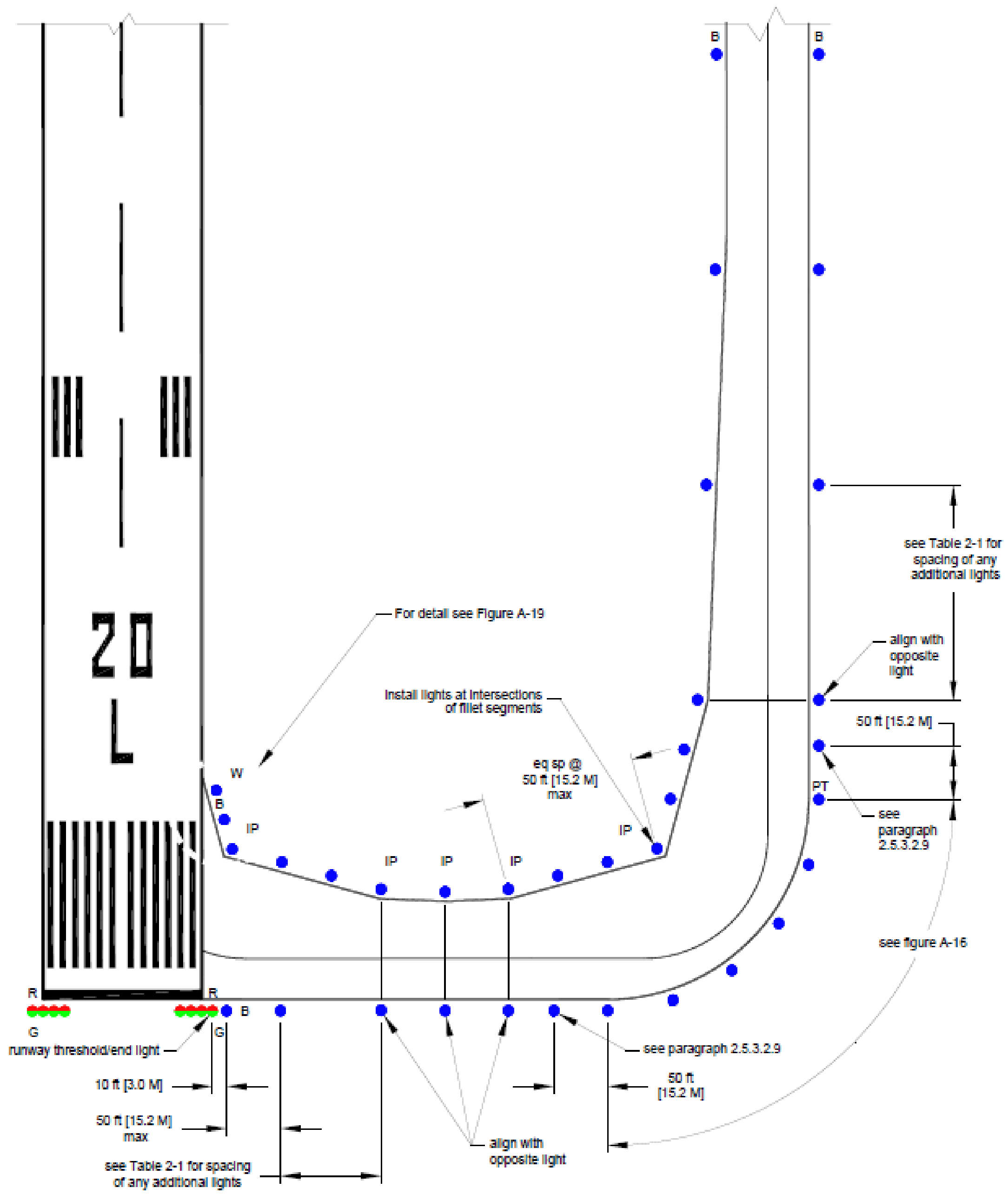
1. Stopway with full runway safety and object free areas available beyond stopway end.
2. Displaced Threshold established due to an obstruction in the approach area.
3. Distance-to-go signs are provided and located with respect to stop end of LDA.
4. All runway markings, including Displaced Threshold area, are white. All taxiways, blast pads, stopways, and unusable pavement markings are yellow.
5. Threshold/Runway End lights (number on each side)
   a. 3 (minimum) - visual operation
   b. 4 (minimum) - instrument operation
   c. 2' - 10' [0.6 M - 3 M] (minimum)
6. If needed to provide visual guidance 360°, red fixtures may be installed on edge lights in the stopway area.
7. Refer to Figure A-1 for lighting legend.
8. Taxiway pavement geometry shown is for reference only. Refer to AC 150/5300-13 for creating taxiway geometry.
9. When the threshold is displaced, the 2 ft [0.6 M] to 10 ft [3.0 M] spacing does not apply for threshold lights. Threshold lights are aligned with the approach side edge of the runway threshold marking.



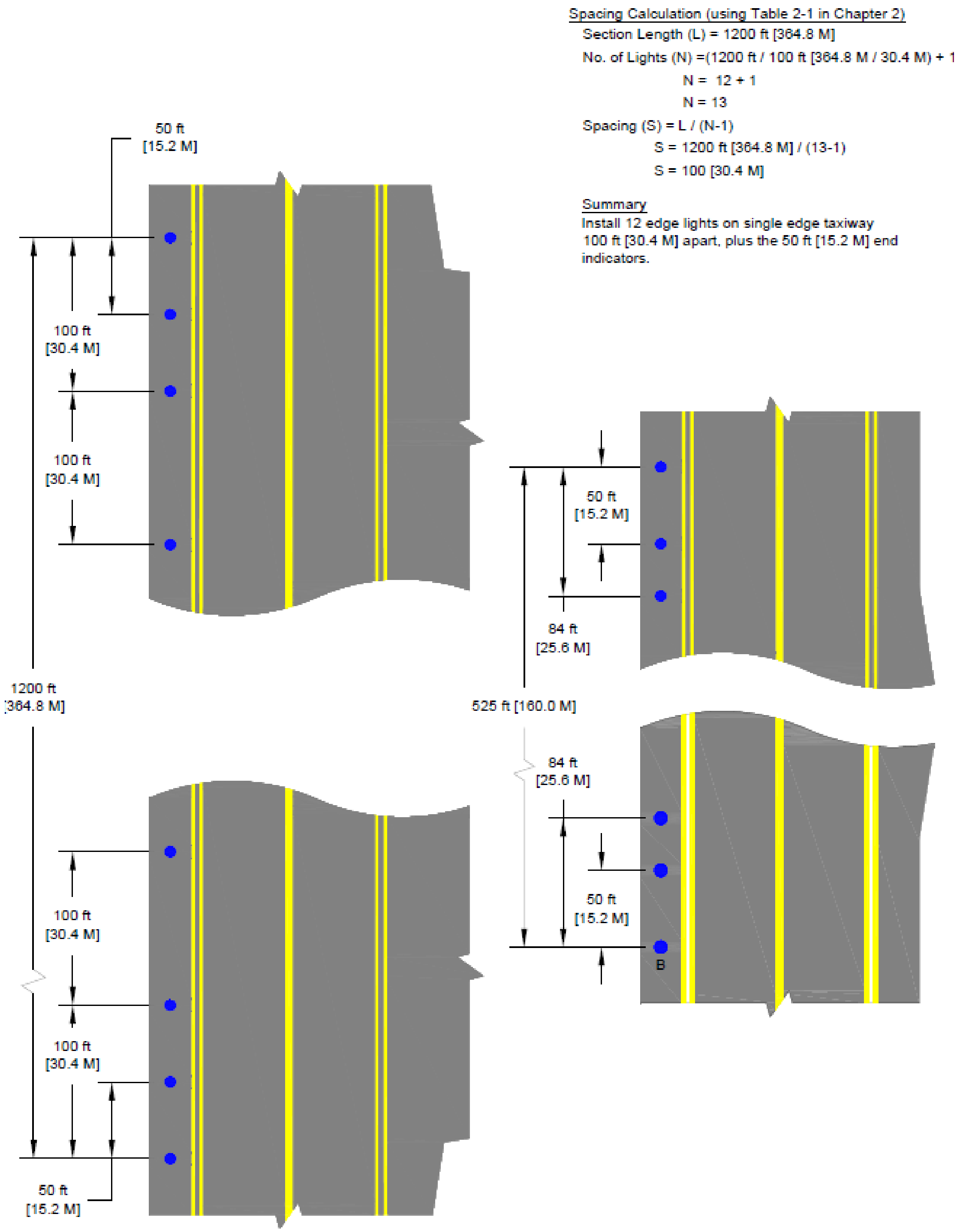
Lighting for Runway with Displaced Threshold and Stopway

NOTES:

1. Refer to Figure A-1 for lighting legend.
2. Taxiway pavement geometry shown is for reference only. Refer to AC 150/5300-13 for creating taxiway geometry.



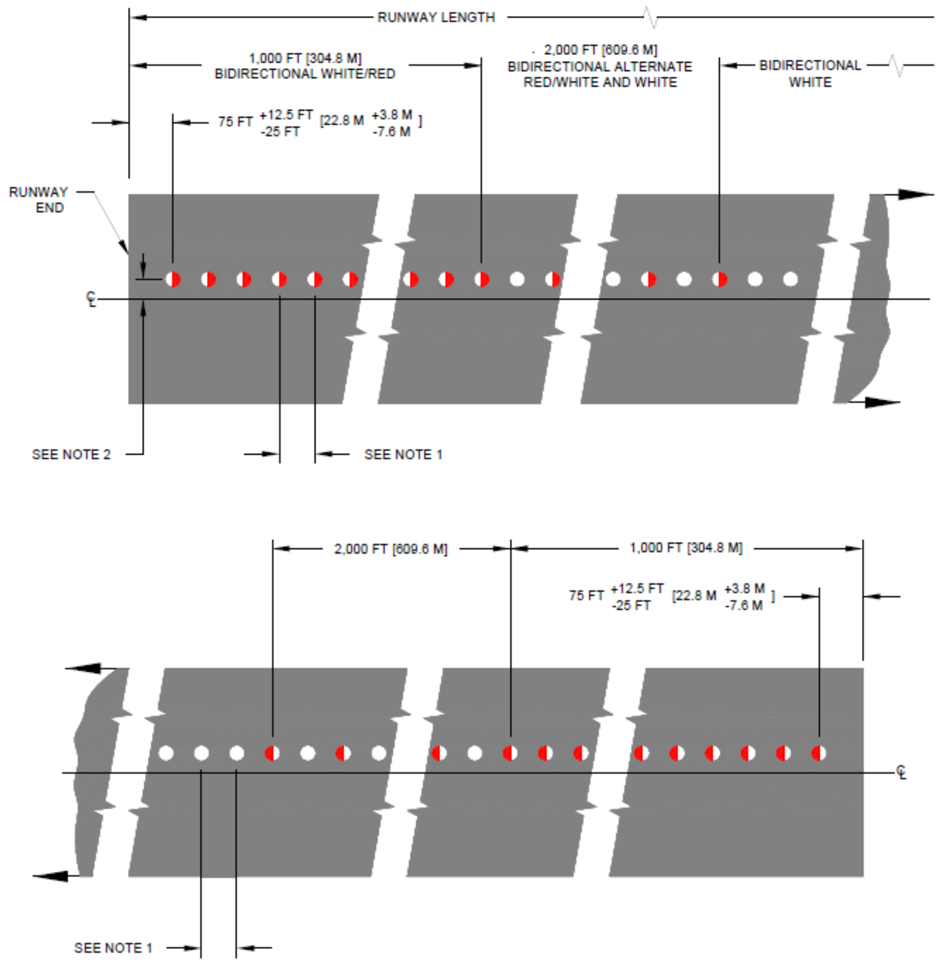
Lighting for Typical Runway Entrance



Typical Single Straight Taxiway Edges (> 200 feet)

RUNWAY CENTERLINE & TOUCHDOWN LIGHTS

Runway centerline and touchdown zone lighting systems are designed to facilitate landings, rollouts, and takeoffs. The touchdown zone lights are primarily a landing aid while the centerline lights are used for both landing and takeoff operations. The runway centerline lights are located along the runway centerline at 50 ± 2 feet equally spaced longitudinal intervals. On runways with centerline lights, the centerline lights are extended into the displaced threshold area. The following figure illustrates the standard runway centerline light configuration:



NOTE:

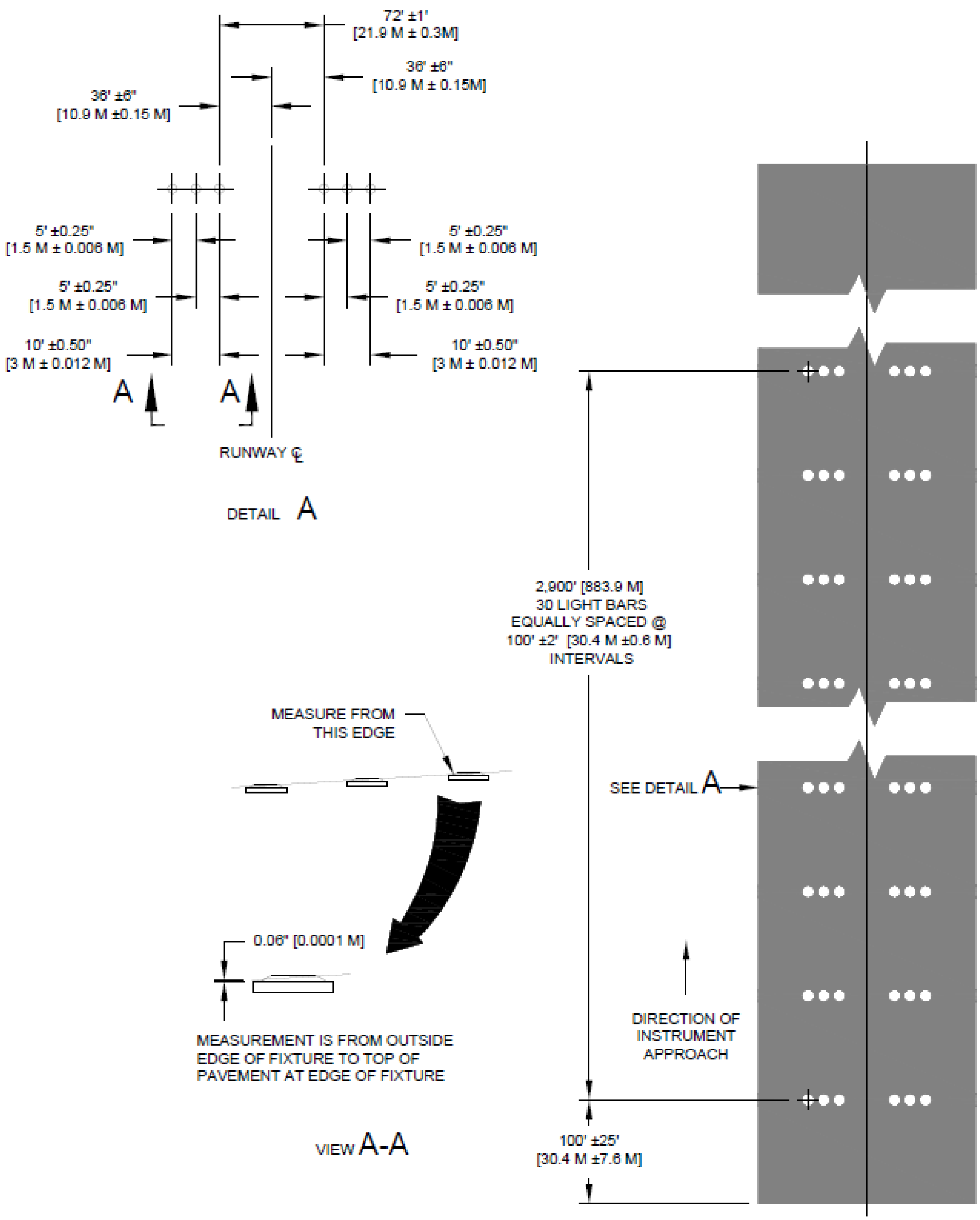
1. REFER TO PARAGRAPH 3.3.1.1 FOR RUNWAY CENTERLINE LIGHT FIXTURES PLACEMENT AND TOLERANCES.
2. SPACE THE RCLs EQUALLY AT 50 FT [15.2 M] FOR THE FAA TYPE L-850A LIGHTS. THE LONGITUDINAL TOLERANCE IS ±2 FT [0.6 M].

LEGEND:

○ BIDIRECTIONAL RCL - WHITE BOTH DIRECTIONS

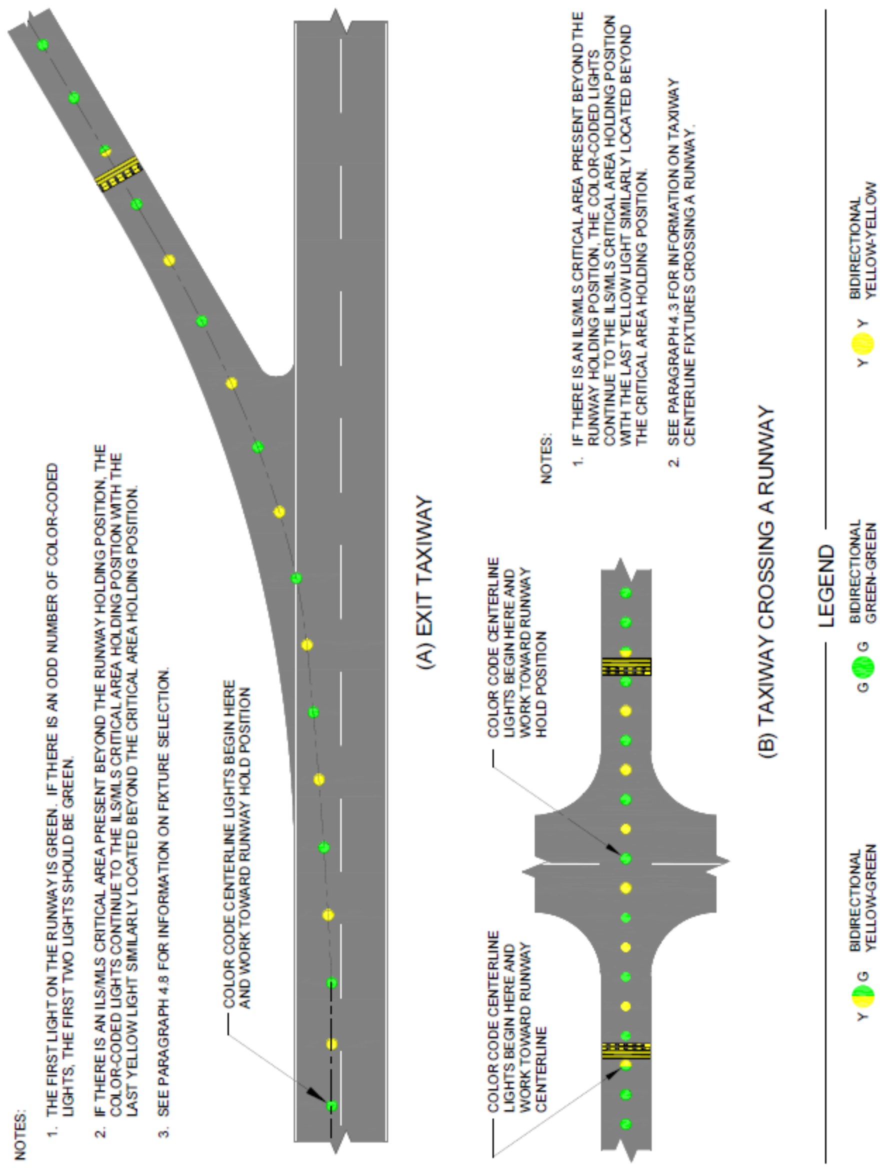
◐ BIDIRECTIONAL RCL - RED IN DIRECTION OF SHADED SIDE
WHITE IN DIRECTION OF WHITE SIDE

Touchdown zone lights consist of two rows of transverse light bars located symmetrically about the runway centerline. Each light bar consists of three unidirectional lights facing the landing threshold. This image demonstrates touchdown zone lighting layout:

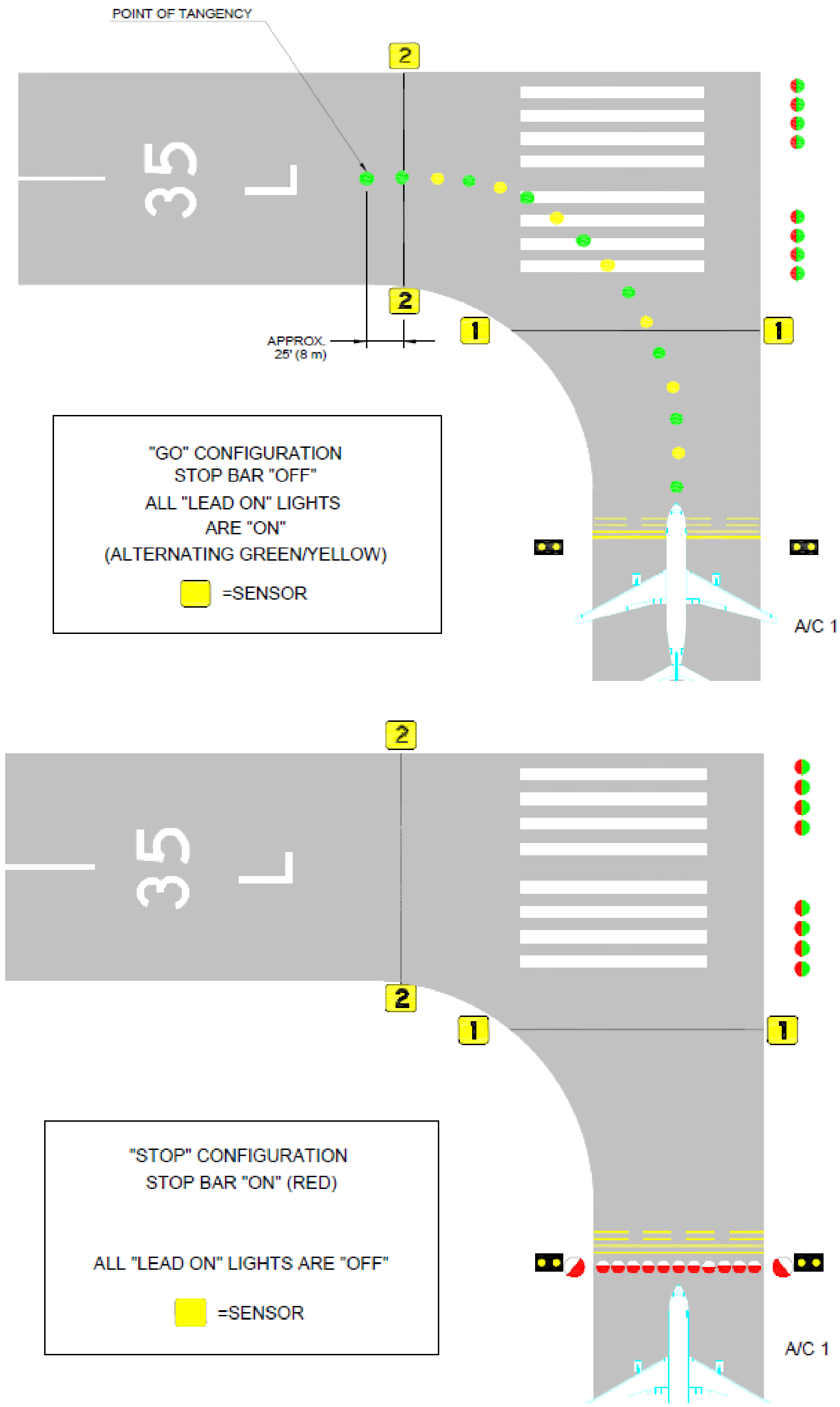


TAXIWAY LIGHTING

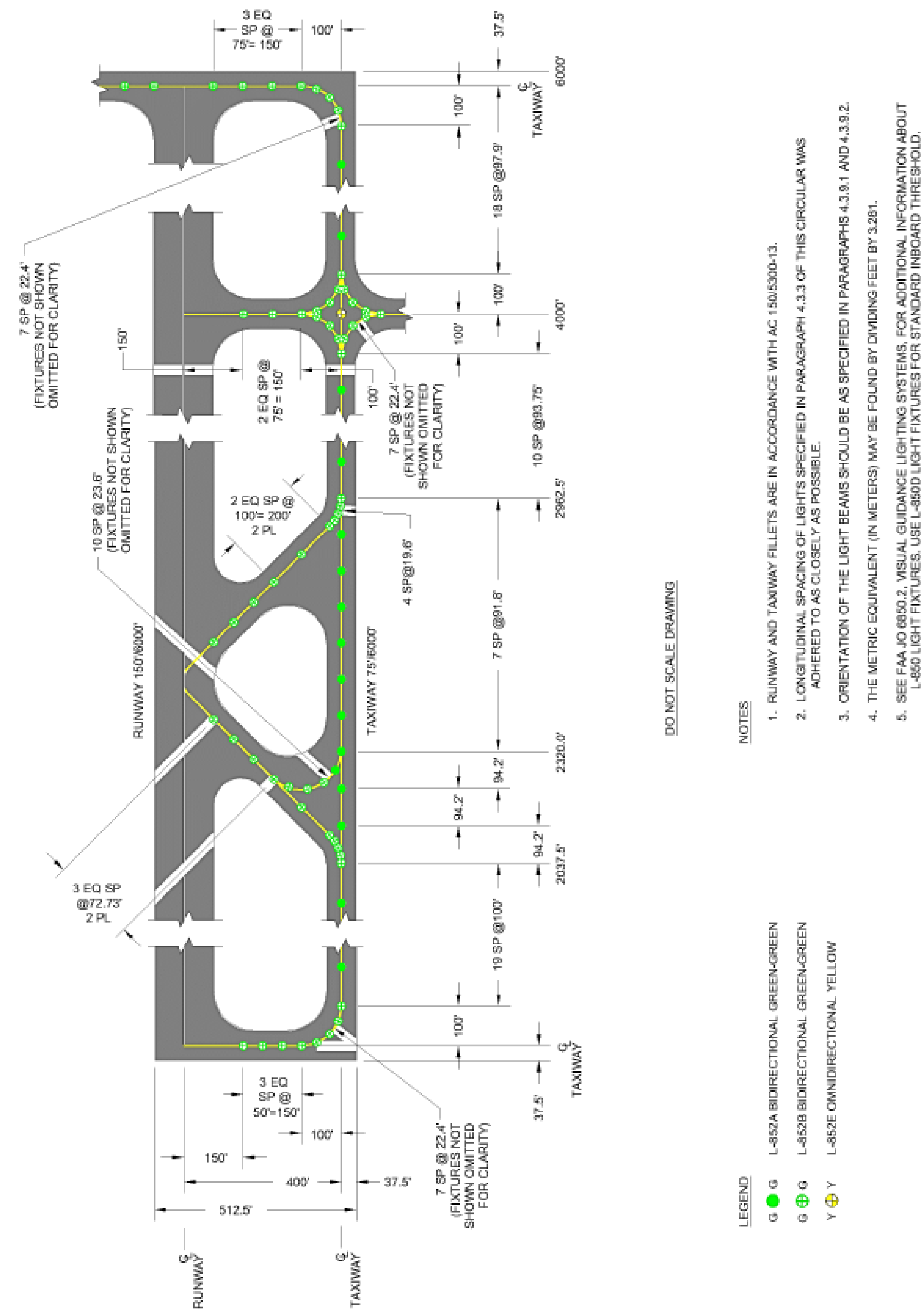
Taxiway lighting systems such as taxiway centerline lights, RGLs, stop bars, and clearance bars are designed to facilitate taxiing and may be required for airport operations during low visibility conditions. Taxiway centerline lights provide taxi guidance between the runway and apron areas. Runway guard lights (RGLs) provide a visual indication to anyone approaching the runway holding position that they are about to enter an active runway. Stop bars provide a distinct "stop" signal to anyone approaching a runway. Clearance bars advise pilots and ground vehicle operators that they are approaching a hold point.



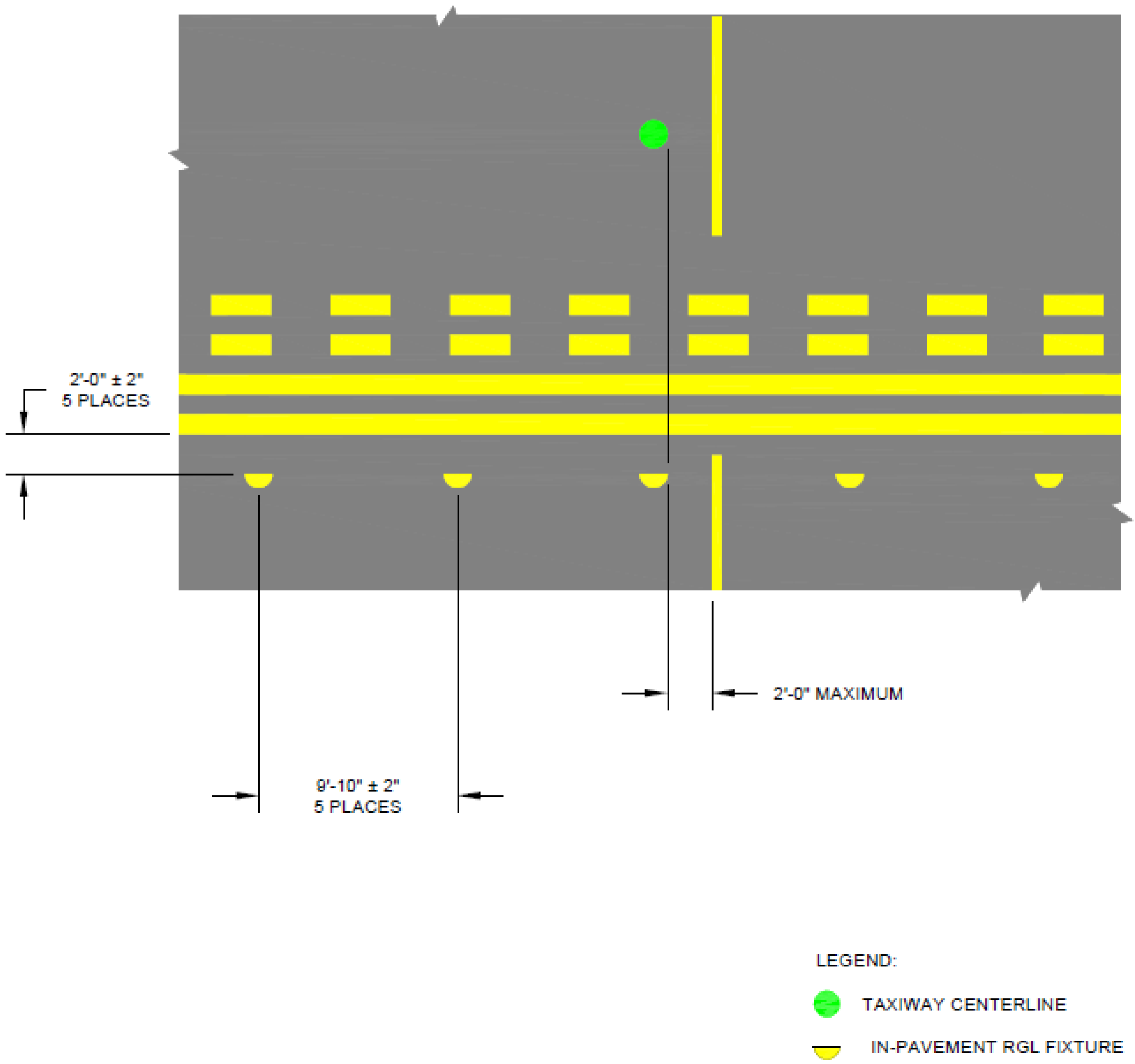
Color-Coding of Exit Taxiway Centerline Lights



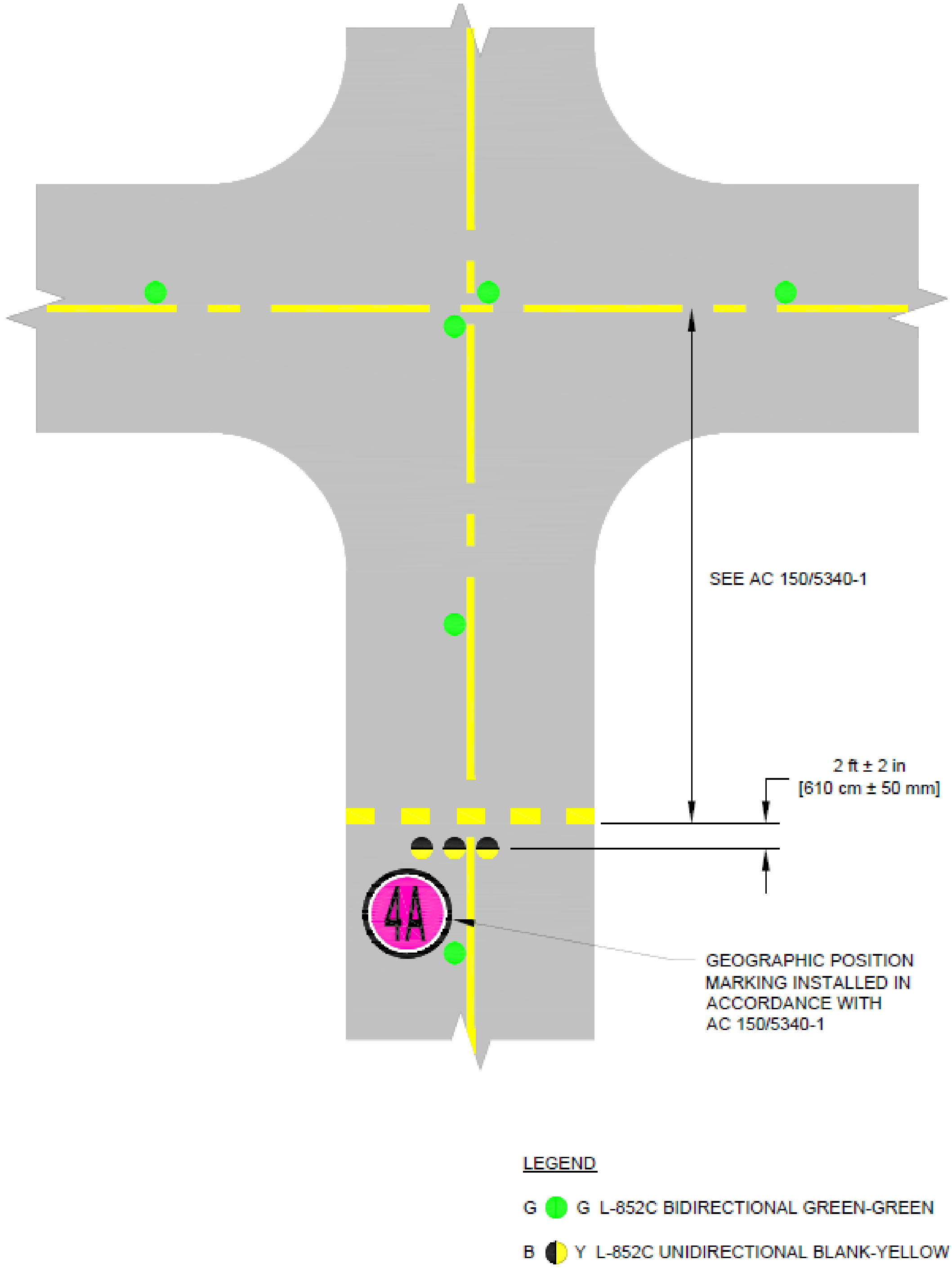
Controlled Stop Bar Design and Operation



Typical Taxiway Centerline Lighting Configuration for Standard Fillets



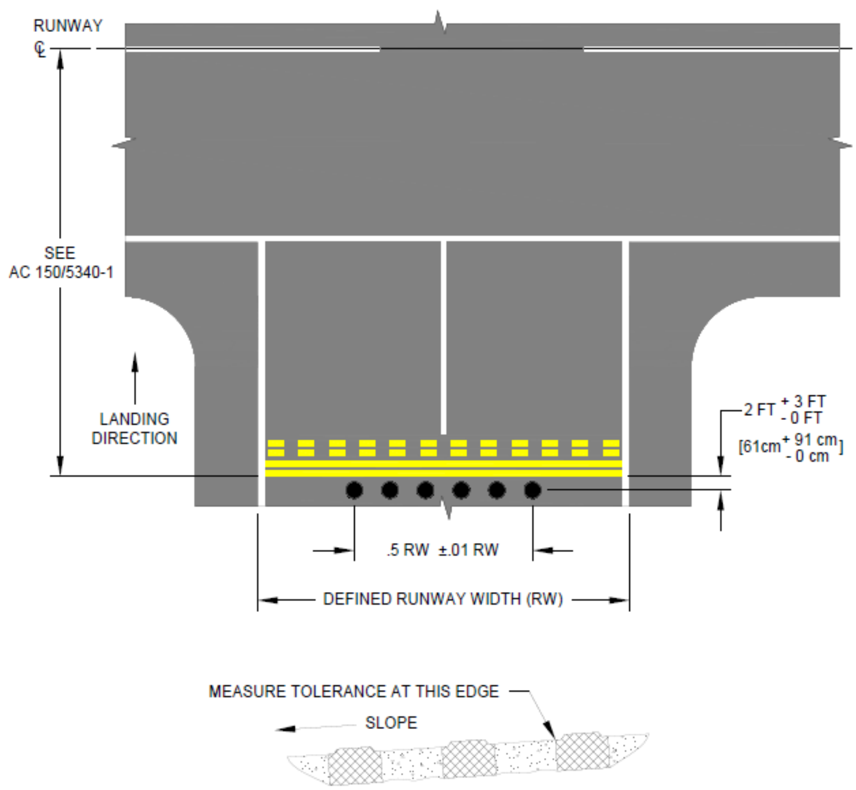
In-Pavement Runway Guard Light Configuration



Clearance Bar Configuration at a Low Visibility Hold Point

Land & Hold Short Lights

Land and hold short lighting systems indicate the location of hold-short points on runways approved for land and hold short operations. A hold short point is a point on the runway beyond which a landing aircraft with a Land and Hold Short Operation (LAHSO) clearance is not authorized to cross. LAHSO includes landing and holding short of an intersecting runway, a taxiway, a predetermined point, or an approach/departure flight path. A land and hold short lighting system consists of a row of six or seven in-pavement pulsing white lights installed across the runway at the hold-short point. A 6-light bar is standard for new installations.



PARTIAL CROSS-SECTION OF RUNWAY AT LAND AND HOLD SHORT LIGHTS

NOTES:

1. THE LIGHT FIXTURES ARE UNIFORMLY SPACED (WITHIN A TOLERANCE OF ± 2 IN. [5 cm] BETWEEN THE OUTBOARD LIGHT FIXTURES.
2. THE LIGHTING SYSTEM IS SYMMETRICAL ABOUT THE RUNWAY CENTERLINE FOR 6-LIGHT SYSTEMS. 7-LIGHT SYSTEMS ARE SYMMETRICAL ABOUT THE CENTER LIGHT FIXTURE, WHICH IS ACCORDING TO THE CRITERIA FOR RUNWAY CENTERLINE, SEE CHAPTER 3.
3. SEE PARAGRAPH 5.5.2 FOR LATERAL SPACING OF 7-LIGHT SYSTEMS.
4. SEE PARAGRAPH 11.1 FOR FIXTURE ALIGNMENT.

Typical Layout for Land and Hold Short Lights

NAVAIDs

Navigation aids (NAVAIDs) are intended to assist pilots during takeoff and landing. There are many forms of NAVAIDs, both on and off the airport. This section introduces many of these devices and generally explains how they operate and how pilots interpret the systems. Some of the less common NAVAIDs are not addressed in this document.

Most ATC equipment and NAVAIDs are owned and maintained by the FAA. Some airports may share ownership with private entities. Each airport has different NAVAIDs; some have none at all.

Although NAVAIDs are useful to pilots, they are also obstacles to aircraft. Therefore, location and installation practices are critical to airport safety. Some systems must be located within the RSA or ROFA and are called “fixed-by-function”. Others can be relocated or placed in locations that are non-hazardous. Also, frangible couplings are to be used to mount objects in airport operation areas. This helps prevent damage to an aircraft that collides with a mounted object. Specific building details and construction of NAVAID-related infrastructure is strictly controlled.

Air Traffic Control Tower (ATCT)

Air traffic control towers are facilities that provide air traffic services on and around the airport. Controllers must have good visibility of the movement areas and takeoff and landing operations, so tower location must be carefully evaluated. The tower must be located at a minimum height that meets visibility performance requirements for all controlled movement areas. Towers may be staffed 24/7 or during daylight hours only.

Remote Transmitter/Receiver (RTR)

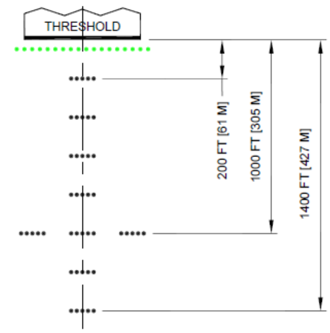
RTR systems provide air-to-ground communication at a terminal facility which allows radio communication between pilots and ATC. Line of sight between the RTR, aircraft, and ATCT is critical.

Airport Surveillance Radar (ASR)

ASR is a radar facility used to detect and display azimuth, range, and elevation of aircraft operating within terminal airspace. ASR antennas scan through 360 degrees to present the controller with the location of all aircraft within 60 nm of the airport. The access to power and communication duct banks to and from the ATCT is an important factor to consider in selecting a location for an ASR facility. The ASR antenna and equipment building should be located as close to the ATCT as practical and economically

feasible. Antennas should be located at least 1,500 feet from any building or object that might cause signal reflections and at least ½ mile from other electronic equipment.

APPROACH LIGHTING SYSTEM (ALS)



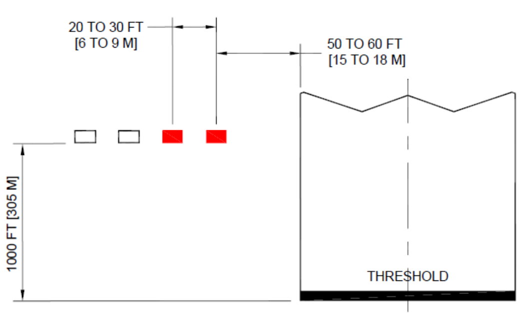
ALSs are configurations of lights positioned symmetrically along the extended runway centerline to aid pilots approaching the runway in low visibility conditions. They begin at the runway threshold and extend towards the approach. The approach lighting is usually controlled by the ATCT, but may be controlled by the airport operator, or by a pilot via VHF radio. An ALS often supplements electronic NAVAIDs, resulting in lower visibility minimums. All ALSs in the United States use a feature called the Decision Bar. The Decision Bar is always located 1,000 feet from the threshold, and it serves as a visible horizon to ease the transition from instrument flight to visual flight. There are several ALS configurations, including ALSF, MALS, MALSR, MALSF, SSALR, LDIN, and ODALS. For the sake of brevity, these variations are not described here; refer to AC 150/5300-13A for details.

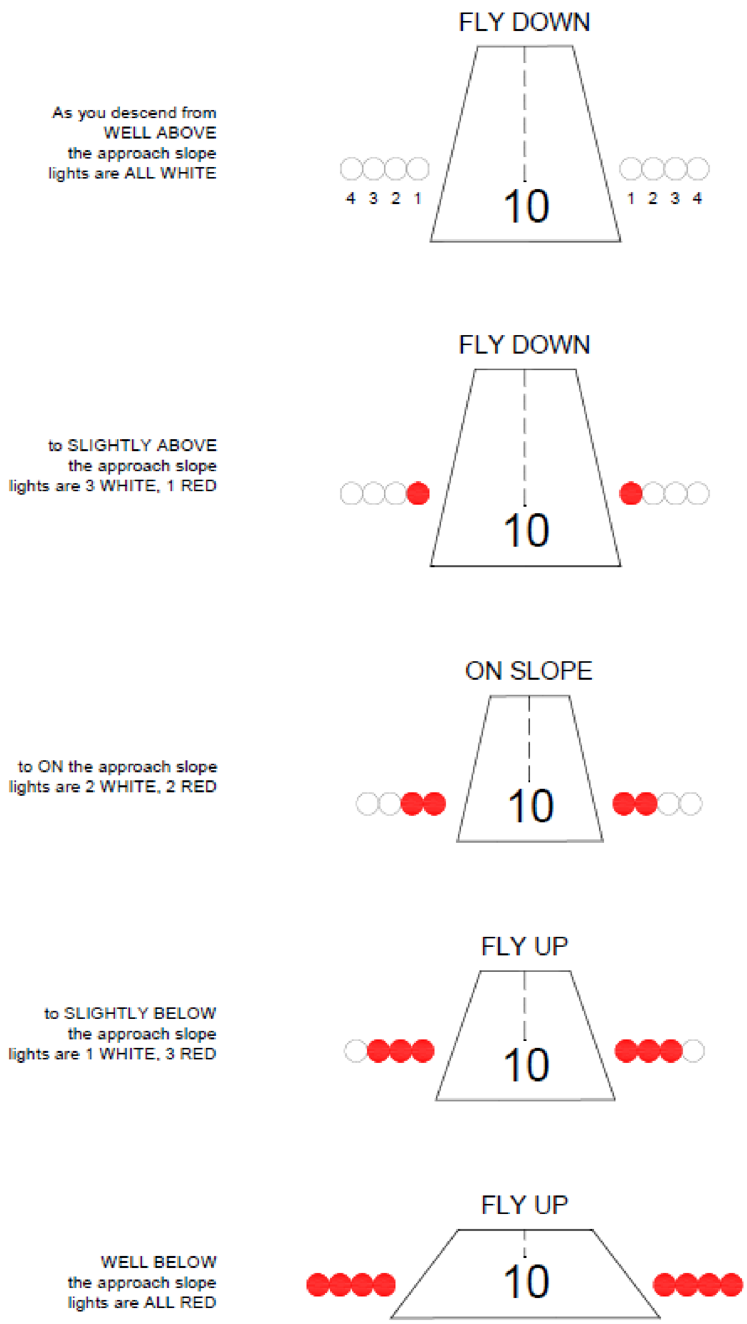
RUNWAY END INDICATOR LIGHTS (REIL)

A REIL consists of a flashing white light installed at each approach end corner of a runway. The function of the REIL is to provide rapid and positive identification of the end of the runway. The lights are directed toward the approach zone, enabling the pilot to identify the runway threshold. These lights consist of two synchronized flashing unidirectional or omnidirectional lights; one on each side of the runway threshold. REIL systems are effective for identification of a runway surrounded by a multitude of other lighting or lacking contrast with surrounding terrain. This system is usually installed at non-towered airports and can be activated by a specified radio frequency known to the pilot.

PRECISION APPROACH PATH INDICATOR (PAPI)

A PAPI is a light array positioned beside the runway. It normally consists of four equally spaced light units color-coded to provide a visual indication of an aircraft's position relative to the designated glideslope for the runway. The specific location depends on a number of factors including: obstruction clearance, Threshold Crossing Height (TCH), presence of a glideslope, and type of aircraft using the runway. Note that the Visual Approach Slope Indicator (VASI) is now obsolete and is replaced by PAPI.





NOTES:

1. THERE IS A PROGRESSIVE CHANGE FROM ALL WHITE TO ALL RED LIGHTS.
2. NORMAL INSTALLATION IS LEFT SIDE ONLY, BUT MAY BE BOTH SIDES OR RIGHT SIDE ONLY.

Rotating Beacons

On an airport, rotating beacons indicate the location of the airfield by projecting alternating white/green beams of light spaced 180 degrees apart. Any airport with runway edge lights is required to have a rotating beacon. Beacon locations should be within 5000 feet of a runway and must not interfere with pilot or air traffic controller vision. It should be mounted high enough so that the beam is not blocked by any object.

Non-Directional Beacon (NDB)

A non-directional beacon is a radio beacon that aids the pilot of an aircraft equipped with direction finding equipment. It can be part of an ILS. NDBs are most commonly used as compass locators for the outer marker of an ILS. NDBs may designate the starting area for an ILS approach or a path to follow for a standard terminal arrival procedure.

Instrument Landing System (ILS)

The ILS provides pilots with electronic guidance for aircraft alignment, descent gradient, and position until visual contact confirms the runway alignment and location. The ILS uses a line-of-sight signal from the localizer (LOC) antenna and marker beacons and a reflected signal from the ground plane in front of the glideslope (GS) antenna. The LOC signal is used to establish and maintain the aircraft's horizontal position until visual contact confirms the runway alignment and location. The LOC antenna is usually sited on the extended runway centerline, outside the RSA between 1,000 to 2,000 feet beyond the stop end of the runway. The GS antenna signal is used to establish and maintain the aircraft's descent rate until visual contact confirms the runway alignment and location. The GS antenna may be located on either side of the runway.

Distance Measuring Equipment (DME)

DME provides pilots with a slant range measurement of distance to the runway in nautical miles. The DME is usually co-located at the LOC when used as a component of the ILS. DMEs are augmenting or replacing markers in many installations. The DME is a terminal area or en route navigation facility that provides the pilot with a direct readout indication of aircraft distance from the identified DME. It can be co-located with a VHF Omnidirectional Range (VOR) and/or a LOC shelter.

Runway Visual Range (RVR)

RVR measures the atmospheric transmissivity along runways and translates this visibility value to the air traffic user. RVRs are needed to support increased landing capacity at existing airports, and for ILS installations. RVR visibility readings assist ATCT controllers when issuing instructions and to avoid interfering operations within ILS critical areas at controlled airports. RVR systems are also used at non-towered airports. The number of RVRs required depends upon the runway approach category and physical length.

Very High Frequency Omnidirectional Range (VOR)

VOR is a system radiating VHF radio signals to compatible airborne receivers. It gives pilots a direct indication of bearing relative to the facility. There are three types of VORs: High Altitude, Low Altitude and Terminal (which is usually located near or at an airport). VOR stations have co-located DME or Tactical Air Navigation (TACAN); the latter includes both the DME distance feature and a separate TACAN azimuth feature that provides data similar to a VOR. A co-located VOR and TACAN beacon is called a VORTAC. A VOR co-located only with DME is called a VOR-DME.

Segmented Circles & Wind Cones

A wind cone visually indicates prevailing wind direction at a particular location on an airfield or heliport. The segmented circle provides visual indication of current airport operations such as active landing direction and traffic patterns. Airports have no more than one segmented circle that is collocated with a wind cone. Additional (supplemental) wind cones are not provided with a segmented circle. Wind cones are commonly supplied with a single obstruction light and four floodlights to illuminate the windsock.

Automated Surface/Weather Observing System (ASOS/AWOS)

Automatic recording instruments measure cloud cover and ceiling, visibility, wind speed and direction, temperature, dew point, precipitation accumulation, icing, sea level pressure for altimeter setting, and lightning. This equipment is often installed at the best location that will provide observations that are representative of the meteorological conditions affecting aviation operations. However, the equipment is not installed inside runway or taxiway OFAs, runway or taxiway safety areas, the Runway Obstacle Free Zone (ROFZ), or instrument flight procedures surfaces and is often installed near glides slope installations.

Reference Material

1. AC 150/5300-13A *Airport Design*; 2-26-2014
2. AC 150/5340-30J *Design and Installation Details for Airport Visual Aids*; 2-12-2018
3. Airport Engineering, Ashford et al., *Wiley & Sons, 4th ed.*
4. Planning and Design of Airports, *Horonjeff et al., McGraw-Hill, 5th ed.*

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