BY ORDER OF THE SECRETARY OF THE AIR FORCE

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Civil Engineering

DESIGN STANDARDS FOR VISUAL AIR NAVIGATION FACILITIES

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This manual provides the guidance and detailed information on standard configurations and equipment to comply with the complementary AFI 32-1044, *Visual Air Navigation Systems.* Use it when designing, planning, constructing, and installing these systems. It does not apply to operation of these systems at Air National Guard Units. When using this manual, be certain that the complementary markings are installed and that no conflict occurs with the placement of light fixtures. Send comments and suggested improvements on AF Form 847, **Recommendation for Change of Publication**, through major commands to HQ AFCESA/CESE, 139 Barnes Drive, Suite 1, Tyndall AFB FL 32403-5319, or HQ USAF/ILE, 1260 Pentagon, Washington DC 20330-1260.

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PART 1 - STANDARDS

Chapter 1

INTRODUCTION TO STANDARDS AND CRITERIA

1.1. Purpose of Chapter. This chapter contains the configuration standards, application and installation criteria, and a listing of applicable specifications for all visual air navigation facilities which will be installed at US Air Force facilities.

1.2. Background. The term "visual air navigation facilities" refers to all the lights, signs, symbols, and other visual aid devices located on and in the vicinity of an airfield. The facilities provide a visual reference and guidance to pilots when operating aircraft on the ground and in the air. The facilities also supplement the guidance provided by markings and electronic aids such as Tactical Air Navigation (TACAN), Precision Approach Radar (PAR), and Instrument Landing System (ILS), for operating aircraft.

1.2.1. Visual facilities must be standardized for operational safety. Standardization means the configuration and color of the lights at each airfield are identical and have the same meaning. Standardization enables a pilot to readily interpret the guidance information with assurance and to react to it with a minimum amount of mental concentration.

1.2.2. According to Public Law 85-726, the Federal Aviation Administration (FAA) regulates and promotes civil aviation to best foster its development and safety, and to provide for the safe and efficient use of the airspace by both civil and military aircraft. The FAA develops, modifies, tests, and evaluates systems, procedures, facilities, and devices. It also defines the performance characteristics needed for safe and efficient navigation and traffic control of all civil and military aviation.

1.3. Application. Use this manual for all major rehabilitation, replacement, or establishment of new visual air navigation facilities at US Air Force installations. Do not install visual air navigation facilities or equipment, other than those covered in this publication, except when an appropriate waiver has been obtained (refer to paragraph 1.8). Exceptions are:

- Where international military standards apply (refer to paragraph 1.5).
- Where Base Rights Agreements apply (refer to paragraph 1.6).
- Where existing facilities configured to prior standards and criteria continue to give satisfactory service (refer to paragraph 1.11).

1.4. FAA Standards. The Air Force generally follows FAA standards which are primarily published as advisory circulars, handbooks, and specifications. However, when they are in conflict with the Air Force requirements, this manual takes precedence.

1.5. International Military Standards:

1.5.1. This manual satisfies the requirements of international military standards whenever possible.

1.5.1.1. North Atlantic Treaty Organization (NATO) Standardization Agreements (STANAG) are promulgated by the NATO Military Agency for Standardization (MAS).

1.5.1.2. Air Standardization Coordinating Committee (ASCC) Air Standards (AIR STDs) are promulgated by representatives of the military air forces of the United States, Canada, Australia, New Zealand, and the United Kingdom.

1.5.2. The applicable international military standard takes precedence over the standards in this manual as follows:

- NATO: At Air Force facilities in NATO theater countries except the United States and Canada, or wherever NATO funding is provided for the work, regardless of location.
- ASCC: At Air Force facilities in New Zealand and Australia.

Information on obtaining copies of these standards can be obtained by contacting: HQ USAF/XOOX, 1815 North Fort Myer Drive, Suite 400, Arlington VA 2209-1809, DSN 426-8422/8436/8445, or commercial (703) 696-8422/8436/8445.

1.6. Base Rights. When the US Air Force constructs an airfield in a foreign country, the United States obtains a Base Rights Agreement. This is an agreement of the foreign states, but not by the Air Force. The provisions of the particular Base Rights Agreement must be observed and they may require that the construction be done according to the standards of the host country. Under such an agreement, and regardless of the conformity of the international standards with the standards of the host country, the host country must approve all plans. It may also be desirable to use equipment produced in the host country.

1.7. Visual and Electronic Aids. Provide visual air navigation aids appropriate for operational requirements and associated electronic aids. See table 2.1, Visual Landing Aids (VLA) Requirements Matrix. Except for Visual Flight Rules (VFR) operation, electronic aids are needed to provide initial positioning and direction information to an approaching aircraft. Visual landing aids ensure a timely and safe transition from the instrument phase to the visual phase of an approach. Failure to provide the necessary visual aids on an instrument runway will negate to some degree the utility of the electronic systems; enhancing a runway with unnecessary visual aids wastes valuable resources with little operational advantage. Do not upgrade visual aids for a higher level of operations unless the runway, taxiway, or helipad is approved for that level, and appropriate electronic aids have or are programmed to be installed. Waivers are required for all deviations.

1.8. Waivers of Requirement. The major command (MAJCOM) may waive requirements of this manual if compliance is not practical or feasible. In exercising this waiver authority, the MAJCOM must not adversely impact the effectiveness or safety of operations for any aircraft which may use the airfield. Funding or budgetary constraints normally are not adequate justification for granting a waiver. Each MAJCOM must establish and document procedures for processing waivers. They may use existing documented procedures, but all procedures must include the following:

1.8.1. The MAJCOM/CE has waiver authority which must not be redelegated.

1.8.2. Coordinate all waiver requests with the Airfield Management and Flying Safety Offices at the base, wing, and MAJCOM level. In accordance with AFI 13-213, Airfield Management and Base Operations, offices must coordinate as necessary with local flying units and the air traffic control agencies (FAA) providing Terminal Instrument Procedures services for the affected locations.

1.8.3. Coordinate with the FAA on waiver requests involving facilities at joint-use airfields as they are subject to the provisions of Federal Aviation Regulation Part 77.

1.8.4. Document approved waivers and make them a part of the permanent facility records, available for examination during inspections.

1.8.5. Forward copies of the complete documentation, including detailed justification, of each approved waiver to:

- HQ AFCESA/CESE, 139 Barnes Drive, Suite 1, Tyndall AFB FL 32403-5319
- AFCEE/DGP 3207 North Road, Brooks AFB TX 78235-5364
- HQ USAF/XOOA 1480 Air Force, Pentagon, Wash DC 20330-1480
- HQ USAF/SEP 1140 Air Force, Pentagon, Wash DC 20330-1140

- HQ AFFSA/XOI 1535 Command Drive, Suite D305, Andrews AFB MD 20762-7002

1.8.6. A waiver is not required where existing facilities meet prior standards and continue to give satisfactory service.

1.9. Metrication of Dimension. Use the International Civil Aviation Organization's (ICAO) standard English or metric equivalents rounded off (for example, 30 meters equals 100 feet), even though they do not represent exact conversions. No change in standard dimensions, tolerances, or performance specifications is needed if they are applied consistently. **NOTE:** Executive Order 12770, *Metric Usage in Federal Government Programs* (July 25, 1991), requires use of metric units in procurement of supplies and services.

1.10. Photometric Basis. Photometric requirements specified in this manual are drawn from standards set by the ICAO**.** They have been augmented and modified as necessary to accommodate special Air Force requirements.

1.11. Existing Facilities. Do not use this manual as a sole basis for advancing standards for existing facilities and equipment, except where necessary for a minimum acceptable level of safety, quality, and performance. You may continue to support existing systems with equipment fabricated to the original specifications until the system is upgraded. If co-mingling of new generation equipment with older equipment is required, make sure the difference in performance does not degrade the system in any way.

1.12. Organization of this Manual. This manual has two parts:

1.12.1. Part 1: Contains the standards which each visual air navigational facility must meet. The information in this section serves as siting criteria for the design of specific installations. This section also provides application criteria to ensure that contemplated installations are appropriate for the purpose.

1.12.2. Part 2: Contains information for each system including an explanation as to purpose, configuration, construction, photometrics, and related equipment guidelines as approved for Air Force use.

Chapter 2

APPLICATION CRITERIA

2.1. Purpose of Chapter. This chapter provides application criteria to ensure that the installation of visual air navigation facilities is appropriate for its intended purpose and that it is sufficient to achieve the desired level of operation.

2.2. Relation to Electronic Facilities. Except for VFR operation, electronic facilities are required to provide initial positioning and direction information to an approaching aircraft. Visual air navigation aids are required to ensure a timely and safe transition from the instrument phase of an approach to its visual phase. The planned operational level for an instrument runway can only be achieved through a combination of appropriate electronic and visual guidance systems. Failure to include required visual aids in the planning of an instrument runway will negate, to some degree, the utility of the electronic systems. Conversely, enhancing of a runway with inappropriate visual aids will only waste valuable resources with little operational advantage.

2.3. Application of Requirements. Use the application criteria in this chapter for planning, budgeting, and installing visual air navigation facilities. Do not initiate the addition or upgrading of visual aids to a higher order of operational requirement unless the runway, taxiway, or helipad has been officially approved for the new level of operation and appropriate electronic aids have been installed or are programmed for installation. Waivers are required for all deviations.

2.4. Matrix of Requirements. The matrix of requirements shown in table 2.1 contains application criteria for operational categories and the related visual aid requirements.

2.5. Reference Documents. When another document is referenced in this manual, use the latest revision or issue that is published.

Table 2.1. Visual Landing Aids (VLA) Requirements Matrix.

	OPERATIONAL		CATEGORY		
FACILITY	**NIGHT VFR**	**NON-PRECISION**	**I**	**II**	**III**
APPROACH AIDS					
High Intensity Approach Light System (ALSF-1)	NR	NR	R (1)	NA	NA
High Intensity Approach Light System (ALSF-2)	NR	NR	NR	R	R
Short Approach Lighting (SALS)	NR	OPT	NA	NA	NA
Simplified Short Approach Lighting (SSALR)	NR	OPT	OPT	NA	NA
Medium Intensity Approach Light System (MALSR)	NR	NR	OPT	NA	NA
Runway End Identifier Lights (REIL)	OPT	OPT	OPT	NA	NA
Precision Approach Path Indicator (PAPI)	R(2)	R(2)	OPT	NA	NA
RUNWAY AIDS					
High Intensity Runway Edge Lights (HIRL)	R	R	R	R	R
Medium Intensity Runway Edge Lights (MIRL)	OPT	OPT	NA	NA	NR
Threshold Lights	R	R	R	R	R

FACILITY	OPERATIONAL NIGHT VFR	NON-PRECISION	CATEGORY I	II	III
Runway End Lights	R	R	R	R	R
Runway Distance Markers (RDM)	R	R	R	R	R
Runway Centerline Lights (RCL)	NR	NR	NR	R	R
Touchdown Zone Lights (TDZL)	NR	NR	NR	R	R
TAXIWAY AIDS					
Taxiway Edge Lights	R	R	R	R	R
Taxiway Centerline Lights	OPT	OPT	OPT	OPT	R
Runway Exit Lights	OPT	OPT	OPT	OPT	R
Runway Guard Lights	OPT	OPT	OPT	R	R
Taxiway Guidance Signs (Informative)	OPT	OPT	OPT	OPT	OPT
Taxiway Guidance Signs (Mandatory)	R	R	R	R	R
MISCELLANEOUS AIDS					
Airfield Identification Beacons	R	R	R	R	R
Wind Cones	R	R	R	NA	NA
Obstruction Lights	R	R	R	R	R
HELIPAD AIDS					
Helipad Perimeter Lights	R	-	-	-	-
Landing Direction Lights	OPT	-	-	-	-
Approach Direction Lights	OPT	-	-	-	-
Helipad Floodlights	R	-	-	-	-
Helipad Beacons	OPT	-	-	-	-
Approach Path Indicator CHAPI	OPT	-	-	-	-

Legend:

R	Required.
OPT	Option as recommended by the wing commander and approved by the MAJCOM
NR	Not required.
NA	Not applicable.
(1)	Consult the MAJCOM for MALSR substitution of an ALSF-1.
(2)	Required only on primary instrument runways

Chapter 3

STANDARDS FOR LIGHTED APPROACH AIDS

3.1. Approach Light System with Sequenced Flashing Lights, (ALSF-1):

3.1.1. Purpose. The ALSF-1 is a high intensity approach lighting system with sequenced flashing lights for operations where CAT I weather minimums are required. This system provides the visual guidance to pilots for alignment of the approaching aircraft with the runway and final corrections before landing at night and during low visibility weather conditions.

3.1.2. Associated Systems. In addition to electronic aids such as ILS, PAR, or Microwave Landing System (MLS), the ALSF-1 should include the following:

3.1.2.1. The runway should be paved and not less than 50 meters (150 feet) wide. The length should not be less than 2,000 meters (6,000 feet), but shorter lengths may be approved for special operating conditions.

3.1.2.2. The runway should be equipped with the following:

- Precision approach runway markings
- High-intensity runway edge lights
- High-intensity threshold lights
- Runway end lights
- Precision Approach Path Indicator

3.1.2.3. The approach should have a paved or stabilized end zone area extending 300 meters (1,000 feet) into the approach area and not less than the runway width. The first 100 meters (300 feet) of this paved or stabilized area should have the same slope as the first 300 meters (1,000 feet) of the runway. The remainder of the paved or stabilized area may have a slope of not more than +/- 1.5 percent.

3.1.2.4. The runway should have a Runway Visual Range (RVR) system.

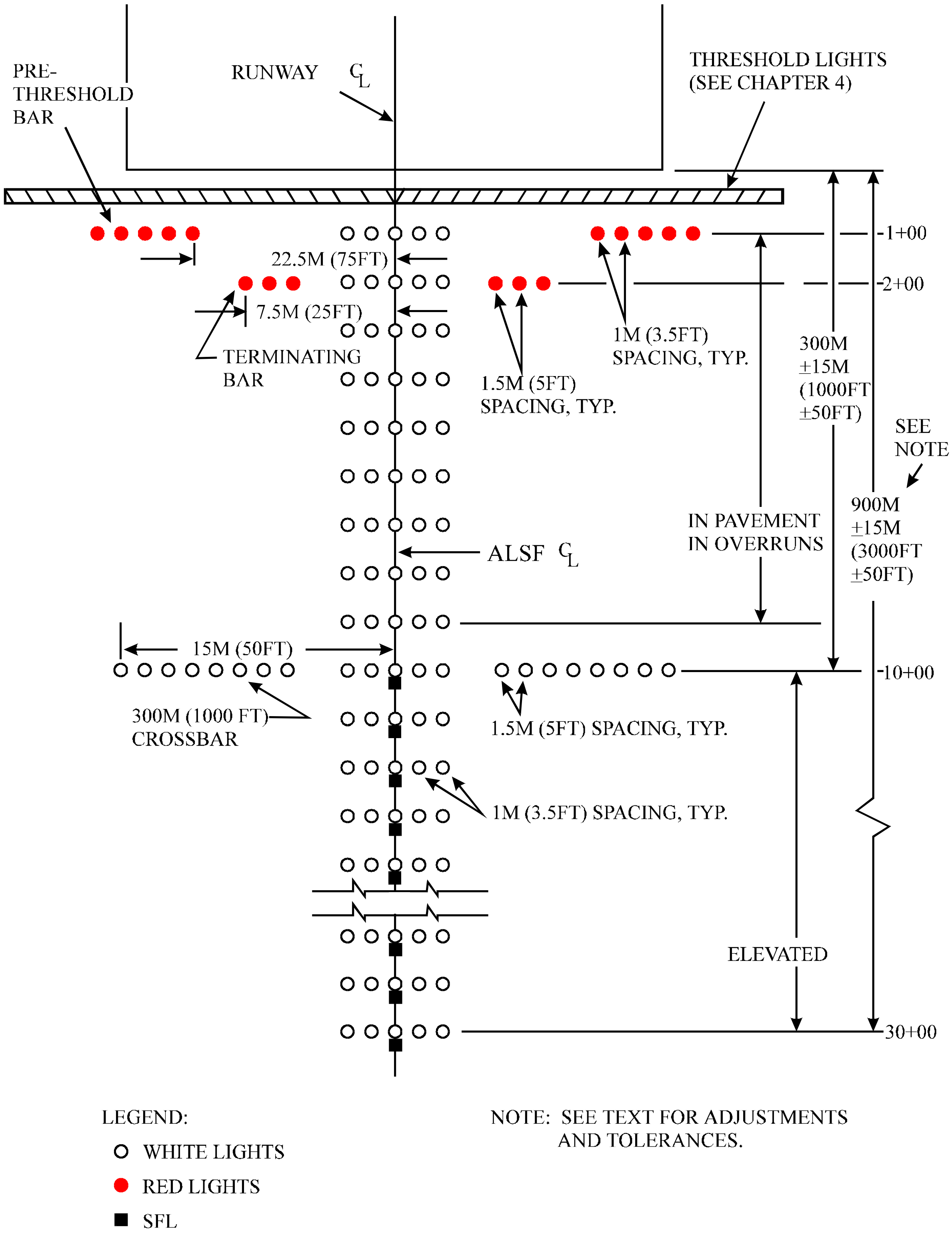
3.1.2.5. Air traffic control should be provided during normal operating hours.

3.1.3. Configuration. The ALSF-1 consists of a pre-threshold light bar, a terminating bar, a 300 meters (1,000 feet) crossbar, centerline lights, sequenced flashing lights, and threshold lights. Figure 3.1 shows the typical layout. The system centerline coincides with the extended runway centerline. The overall system length is 1,000 meters (3,000 feet) extending from the runway threshold into the approach zone. If terrain or other local conditions prevent a full length installation, the system may be shortened to not less than 800 meters (2,400 feet). There is a generally accepted convention for locating lights along the longitudinal axis of approach light systems for this standard. The longitudinal axis is divided into 30 meters (100 feet) stations with station 0+00 located at the threshold and higher station numbers located further into the approach. Thus, a light at station 1+34 would be located 40.3 meters (134 feet) into the approach from the threshold. All lights in the system are aimed toward the approach. Required locations and configurations of the individual system elements are:

3.1.3.1. Pre-threshold Bar. The pre-threshold bar consists of two barrettes in aviation red lights placed symmetrically about the system centerline at station 1+00. Each barrette consists of five lights on 1 meter (3.5 feet) centers, with the innermost lights located not less than 22.5 meters (75 feet) nor more than 24 meters (80 feet) from the system centerline.

3.1.3.2. Terminating Bar. The terminating bar consists of two barrettes in aviation red lights located symmetrically about and perpendicular to the system centerline at station 2+00. Each barrette consists of three lights on 1.5 meters (5 feet) centers, with the outermost lights located 7.5 meters (25 feet) from the system centerline.

Figure 3.1. ALSF-1 Configuration.



3.1.3.3. 300 meters (1,000-foot) Crossbar. This crossbar consists of two barrettes in aviation white lights located symmetrically about and perpendicular to the system centerline at station 10+00 and in line with the centerline barrette at that station. Each barrette consists of 8 lights on 1.5 meters (5 feet) spacing with the outermost light located 15 meters (50 feet) from the system centerline.

3.1.3.4. Centerline Lights. The centerline lights consist of a series of barrettes in aviation white lights located at 30 meters (100 feet) intervals along the system centerline, from station 1+00 to station 30+00. Each barrette consists of five lights spaced at 1 meter (3.5 feet) on centers, centered on and perpendicular to the system centerline. Centerline lights installed on elevated supports may be spaced at 1.02 meters (40.5 inches) in order to fit standard support hardware.

3.1.3.5. Sequenced Flashing Lights (SFL). The sequenced flashing lights are a series of flashing lights located on the system centerline at each station, beginning at station 10+00, 300 meters (1,000 feet) to the end of the system at station 30+00. The lights flash a bluish-white light at a rate of twice per second in sequence from the outermost light station toward the threshold, appearing as a ball of white light traveling toward the runway. Sequenced flashing lights may be uniformly mounted a maximum of 1.3 meters (4 feet) below the steady burning lights, or when in pavement lights are used, they may be displaced a maximum of 1.5 meters (5 feet) into the approach along the system centerline in order to avoid visual or physical interference between light units.

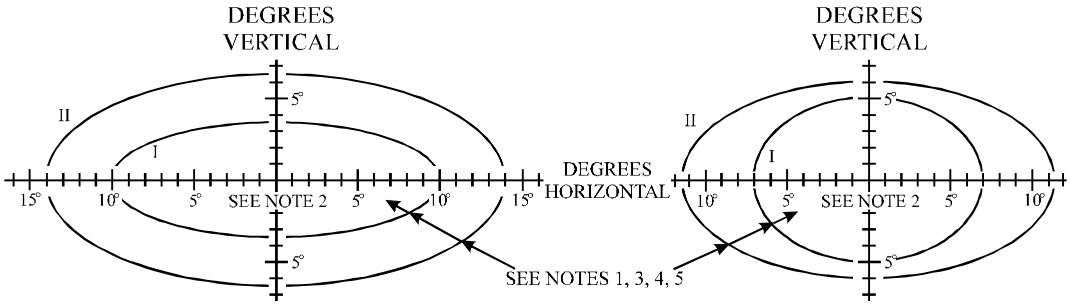
3.1.3.6. Threshold Lights. While threshold lights are not actually a section of the approach light system, they shall be present and installed according to paragraph 4.4.

3.1.4. Photometrics. Optimum aiming of lights depends on the design and light output of the fixtures used in the system. Light fixtures may be designed to cover several applications and may have fixed patterns and aiming angles which differ from the standard. Light aiming and patterns other than those given in this standard may be used, provided the resultant light pattern produces equivalent light intensities in the areas required by the standard. Luminous characteristics for the lights used in this system are described below. The beam widths are measured symmetrically about the optical axis of the light unit unless otherwise noted. All steady burning lights used in the system shall meet the intensity requirements given in figure 3.2. Sequenced flashing lights shall provide, at the maximum intensity setting, an effective intensity of 15,000 candelas (cd) in an elliptical area subtending beam angles of +/- 15 degrees horizontally and +/- 5 degrees measured vertically from the beam axis.

3.1.4.1. Intensity Control. Provide brightness control with five intensity steps for steady burning lights and three intensity steps for flashing lights. The intensity of the sequenced flashing lights shall be coupled to the intensity of the steady burning lights as follows:

Intensity step	Steady Light Intensity Percentage	Flashing Light Intensity Percentage
1	0.16	2.00
2	0.8	2.00
3	4.00	10.00
4	20.00	100.00
5	100.00	100.00

Figure 3.2. Approach Lighting Photometrics.



A. ELEVATED APPROACH LIGHTS; CENTERLINE 300M (1000FT) CROSSBAR (STA 10+00 TO 30+00)

B. SEMIFLUSH WHITE OR RED APPROACH LIGHTS; CENTERLINE OR SIDE ROW (STA 1+00 TO 9+00)

	I=50%	II=10%
a	10.0°	14.0°
b	5.0°	6.5°

	I=50%	II=10%
a	7.0°	11.5°
b	5.0°	6.0°

NOTES:

1. ALL CONTOURS ARE ELLIPSES CALCULATED BY EQUATION $\frac{X^2}{a^2} + \frac{Y^2}{b^2} = 1$
2. THE MINIMUM AVERAGE INTENSITY OF THE MAIN BEAM (INSIDE CONTOUR I) IS 20,000 CD FOR WHITE, OR 5000 CD FOR RED.
3. MAXIMUM INTENSITY SHOULD NOT EXCEED 1.5 TIMES ACTUAL AVERAGE INTENSITY.
4. MINIMUM INTENSITY OF I=50% AND II=10% OF REQUIRED MAIN BEAM INTENSITY.
5. FOR SEMIFLUSH UNITS, THE PORTION OF LIGHT CUT OFF BY THE MOUNTING SURFACE MAY BE DISREGARDED.

3.1.4.2. Aiming Criteria. The beams of all approach lights shall be aimed into the approach zone and away from the threshold. Some approach threshold lights may be bi-directional and will have the red light beam (as a runway end light) aimed along the runway.

- All lights except bi-directional lights with toe-in shall be aimed with the beam axis parallel to the extended runway centerline. Some elevated threshold lights and some existing in pavement threshold lights may have a 3.5 to 4.0 degree toe-in toward the runway centerline which shall be allowed in aiming.
- The vertical aiming of the elevated, uni-directional, steady burning lights shall be aimed with elevation angles in accordance with table 3.1. These aiming angles are based on a glide slope of three degrees. If other glide slope angles are used, the vertical aiming shall be adjusted for the difference. The in pavement lights and the elevated bi-directional threshold lights have fixed angles for the beams. Some existing SFL may also have fixed elevation angles for the beam.

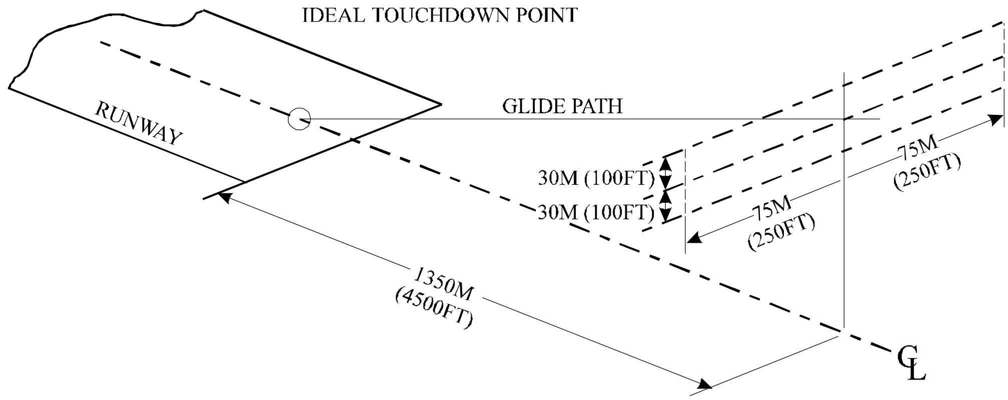
Table 3.1. Elevation Setting Angles for ALSF-1.

STEADY-BURNING TYPE FAA-E-982 LIGHTS					
Station	Setting Angle above Horizontal* (Degrees)		Station	Setting Angle above Horizontal * (Degrees)	
	Preferred	Permitted		Preferred	Permitted
30+00	8.0	8.0	14+00	7.0	7.0
29+00	7.9	8.0	13+00	6.9	7.0
28+00	7.9	8.0	12+00	6.9	7.0
27+00	7.8	8.0	11+00	6.8	7.0
26+00	7.7	7.5	10+00	6.7	6.5
25+00	7.6	7.5	9+00	6.7	6.5
24+00	7.6	7.5	8+00	6.6	6.5
23+00	7.6	7.5	7+00	6.5	6.5
22+00	7.5	7.5	6+00	6.5	6.5
21+00	7.4	7.5	5+00	6.4	6.5
20+00	7.4	7.5	4+00	6.3	6.5
19+00	7.3	7.5	3+00	6.3	6.5
18+00	7.2	7.0	2+00	6.2	6.0
17+00	7.2	7.0	1+00	6.2	6.0
16+00	7.1	7.0	0+00	6.1	6.0
15+00	7.0	7.0			

* For approach slopes other than 3 degrees, the setting angles shall be adjusted for the difference.
Tolerances are +/- 0.2 degrees.
Elevated SFL are all aimed 6 degrees above horizontal.

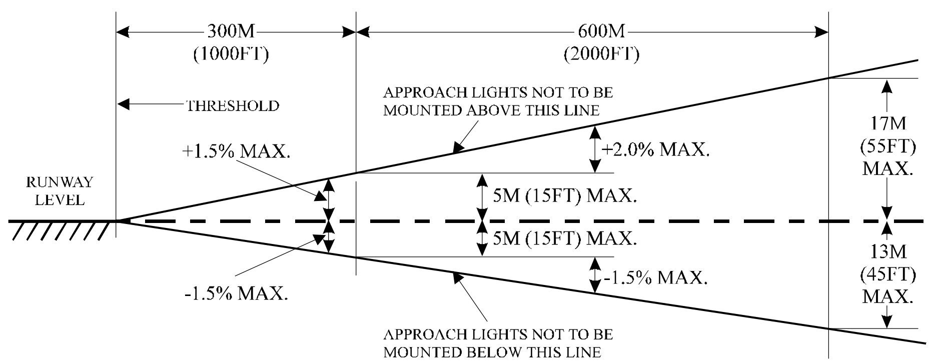
3.1.4.3. Approach light plane. No object will be permitted to obstruct the visibility of an approach light from the viewing window, as shown in figure 3.3. The viewing window is a rectangle 30 meters (100 feet) above and below and 75 meters (250 feet) left and right of the ideal glide path at 1,350 meters (4,500 feet) before the runway threshold. A light plane (figure 3.3), in which the lights of the system are located, is used to determine obstruction clearances of the approach lights. The side boundaries of the light plane are 60 meters (200 feet) on each side of the runway centerline extended. The end boundaries are at the runway threshold and at 60 meters (200 feet) before the start of the approach light system. All lines in the plane perpendicular to the centerline are level. The ideal light plane is a single horizontal plane through the runway threshold. If the 300 meters (1,000 feet) of the runway extending upwind from the threshold is sloped, the first 100 meters (300 feet) of the paved or stabilized area of the end zone and the light plane for this area shall continue with the same slope. The final 235 meters (700 feet) of the paved or stabilized area may have a slope of not more than 1.5 percent up or down. From the 300 meters (1,000 feet) crossbar to the beginning of the approach light system, the preferred light plane is horizontal and will include 1,000-foot crossbar lights. If the clearance of obstructions or terrain prohibits using a horizontal light plane, this plane may be sloped. The slope of this plane shall not exceed 2 percent up or 1.5 percent down, under normal conditions as shown in figure 3.4. The preferred light plane in the area beyond the 300 meters (1,000 feet) crossbar is a single plane, but changes in the slope of the plane are permitted. All light planes shall start and end at a light station and shall contain not less than three light stations. The slope may be increased up to 3.5 percent under special circumstances to avoid obstructions, however a waiver for this condition is required.

Figure 3.3. Viewing Window for Approach Lights.



NOTE: OBSTRUCTIONS SHOULD BE CLEARED SO THAT ALL LIGHTS OF THE APPROACH PATH WILL BE VISIBLE FROM ANY POINT IN A 60M X 150M (200FT X 500FT) RECTANGLE, CENTERED ON THE GLIDE PATH, 1350M (4500FT) FROM THE THRESHOLD.

Figure 3.4. Light Plane Elevation Limits.



NOTE: THE BOUNDARIES OF THE LIGHT PLANES ARE THE RUNWAY THRESHOLD, 60M (200FT) AHEAD OF THE END LIGHT STATION, AND 60M (200FT) EACH SIDE OF CENTERLINE.

3.1.4.4. Light plane obstructions. No objects, except elevated lights of the ALSF-1 in the end zone, should be permitted to extend above the light planes within the boundaries. Objects that extend 7.5 meters (23 feet) above all railroads are considered as obstructions. Objects that extend 6 meters (17 feet) above the highest point of the road surface of interstate highways are considered as obstructions. Objects that extend 5 meters (15 feet) above extend above other highways, public roads, and parking areas are considered as obstructions. Private or military roads are considered as objects 3 meters (10 feet) or higher, except for airport service roads where all vehicular traffic is controlled by the airport control tower, or have signs requiring stopping and visual clearance for aircraft before proceeding, and parking or stopping is prohibited between the signs. Every effort must be made to remove or relocate objects which penetrate the light plane. For objects which cannot be moved, such as an ILS localizer, the height must be kept to a minimum and shall be located as far from the threshold as possible.

3.1.4.5. Installation Tolerances. The tolerances for positioning ALSF-1 and ALSF-2 lights are as follows:

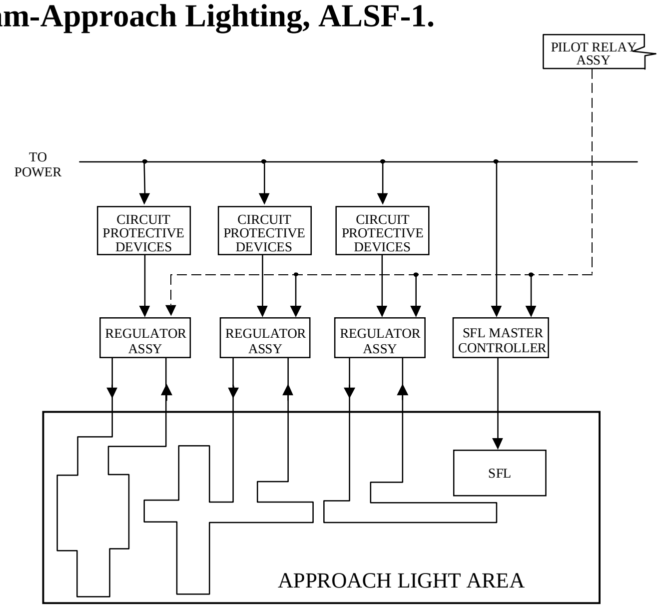
- Light stations shall be installed longitudinally within 6 inches (150 millimeters) of the designated location.
- The lateral tolerance for installation of a light bar is +3 inches (75 millimeters).
- The tolerance for distance between individual lights is +1 inch (25 millimeters).
- Mounting heights tolerances are:

Support Height	Tolerances
0-6 ft (0-2m)	1 in. (25 mm)
6+ft –40 ft (2-12m)	2 in. (50 mm)
40+ft (12+ m)	3 in. (75 mm)

- Deviation from a line perpendicular to the Approach Landing System (ALS) centerline is +1 inch (25 millimeters) maximum.
- Vertical angular alignment of a light shall be within 1degree.
- Horizontal angular alignment of a light shall be within 5 degrees.
- Light stations shall be installed within 6 inches (150 millimeters) of the station designation.

3.1.5. Power Requirements. Provide a main and on-site standby power system, with automatic transfer within 15 seconds of a failure of the power system in use. Do not locate the power and control substation or the standby power equipment within the approach light area shown in figure 3.5.

Figure 3.5. Block Diagram-Approach Lighting, ALSF-1.



3.1.6. Control requirements. Provide remote on and off and five-step intensity control for the steady burning lights. Provide new systems or systems receiving major upgrades with the capability of being electrically switched from the ALSF-1 configuration to the SSALR configuration described in paragraph 3.4.

3.1.7. Monitoring requirements. Monitoring is not required for Category I operation. For operations below 720 meters (2,400 feet) RVR, monitoring is required which, at a minimum, gives positive indication at the control facility indicating power is being delivered to the lights.

3.1.8. Equipment. See Chapter 12, paragraph 12.9.2 for typical ALSF-1 components.

3.1.8.1. Fixtures. Use in pavement fixtures in paved overruns and in displaced thresholds, or where they are subject to damage by jet blast. No part of the unit shall extend more than 25 millimeters (1 inch) above surrounding pavement. All other fixtures shall be elevated and capable of being aimed as required by the standard.

3.1.8.2. Fixture Support. Support elevated fixtures on frangible, low-impact resistant, or semi-frangible supports depending on the required mounting height:

Mounting Height	Support Type
0-2 meters (0-6 ft)	Frangible
2-12 meters (6-40 ft)	Low Impact Resistant
12+ meters (40+ ft)	Semi-frangible

3.1.9. Compliance with International Military Standards:

3.1.9.1. ASCC. This standard meets the requirements for a type B approach light system, as described in ASCC AIR STD 65/35, Aerodrome lighting, Section One.

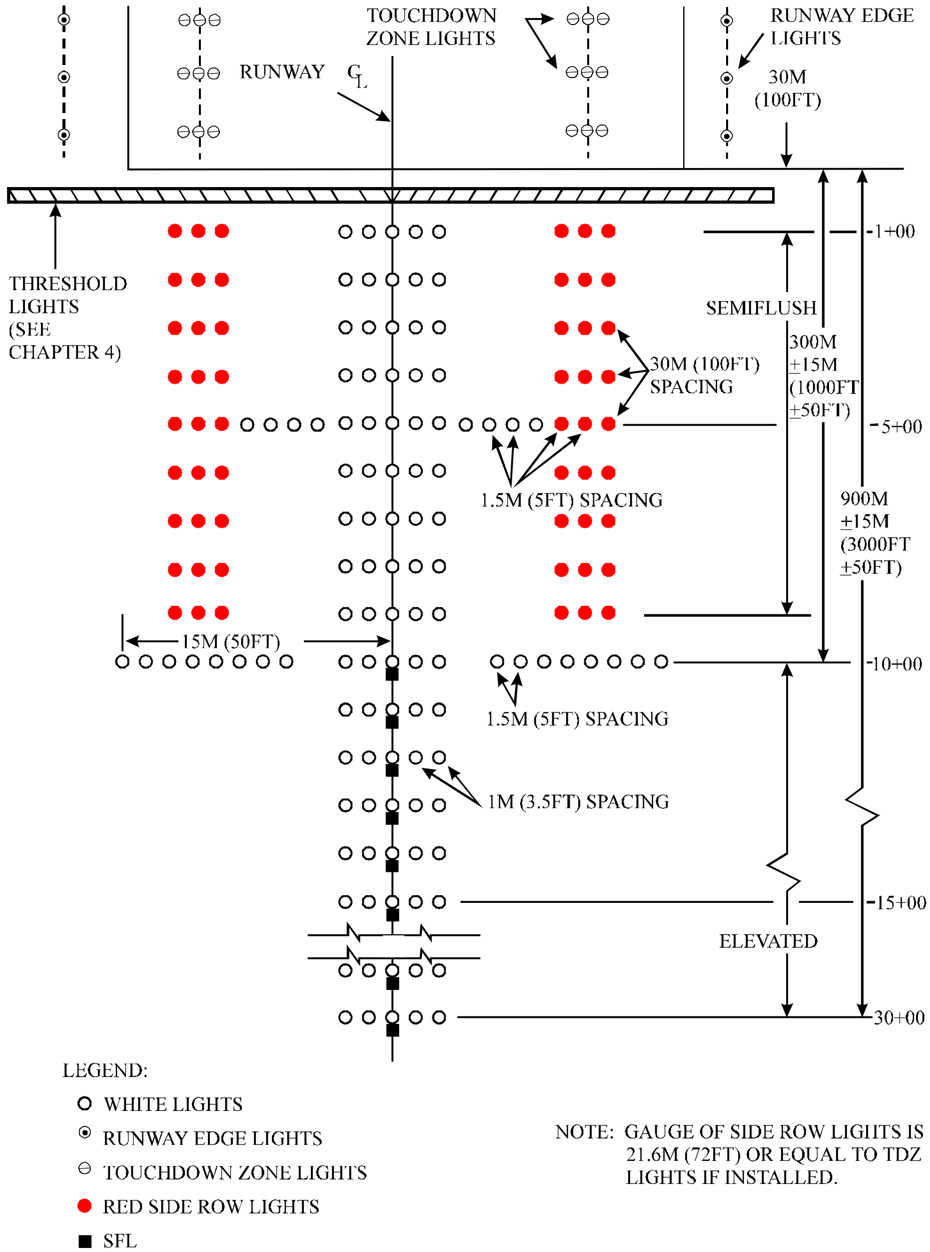
3.1.9.2. NATO. This standard meets requirements for a Type 2 approach lighting system as described in NATO STANAG 3316, Airfield Lighting, except for the vertical aiming of the lights.

3.2. Approach Light System With Sequenced Flashing Lights (ALSF-2):

3.2.1. Purpose. The ALSF-2 is a high intensity approach light system, for operations under Category II or Category III weather minimums.

3.2.2. Configuration. The ALSF-2, as shown in figure 3.6, is configured as an ALSF-1 system modified as follows:

Figure 3.6. ALSF-2 Configuration.



3.2.2.1. Pre-threshold bar. The red lights at the pre-threshold bar are removed.

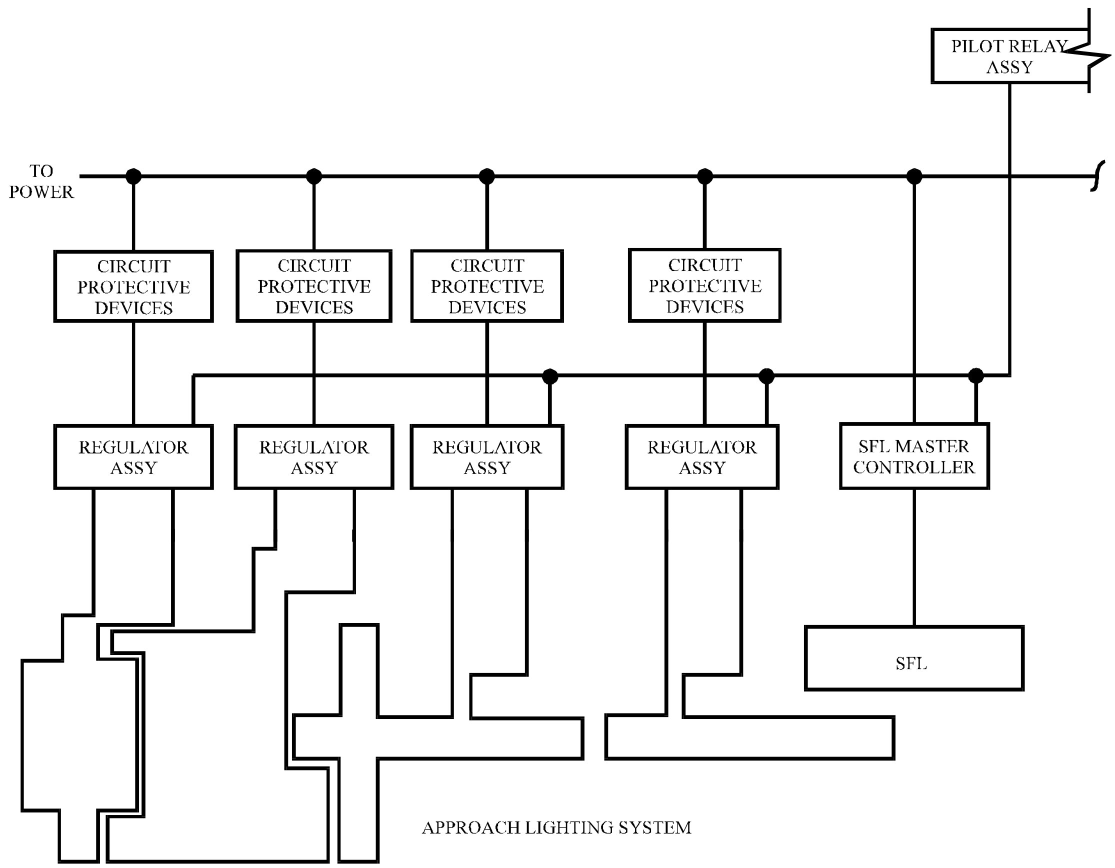
3.2.2.2. Terminating bar. The red lights at the terminating bar are removed.

3.2.2.3. 150 meters (500 feet) bar. A 150 meters (500 feet) bar is added. It consists of two barrettes of aviation white lights, located symmetrically about and perpendicular to the runway centerline, in line with the centerline barrette at that station. Each barrette consists of four aviation white lights on 1.5 meters (5 feet) centers, centered in the space between the centerline lights and the side row lights.

3.2.2.4. Side row lights. Side row lights are added to the inner nine lights stations at stations 1+00 through 9+00. They consist of barrettes containing three aviation red lights, located symmetrically about and perpendicular to the extended runway centerline at each of the light stations 1+00 through 9+00. the lights in each barrette are on 1.5 meters (5 feet) centers, with the innermost light spaced 11 meters (36 feet) from the extended runway centerline.

3.2.3. Photometrics. The requirements in paragraph 3.1.4 for ALSF-1 apply.
3.2.4. Aiming Criteria. The aiming criteria as specified in paragraphs 3.1.4.2 through 3.1.2.4 for ALSF-1 apply, except that the red side row lights shall be aligned with any existing touchdown lights.
3.2.5. Power Requirements. Provide a main and a standby power system, with automatic transfer time within 1 second of a failure of the system that is in use. See system block diagram at figure 3.7 and Chapter 11 for additional design guidance.

Figure 3.7. Block Diagram-Approach Lighting, ALSF-2.



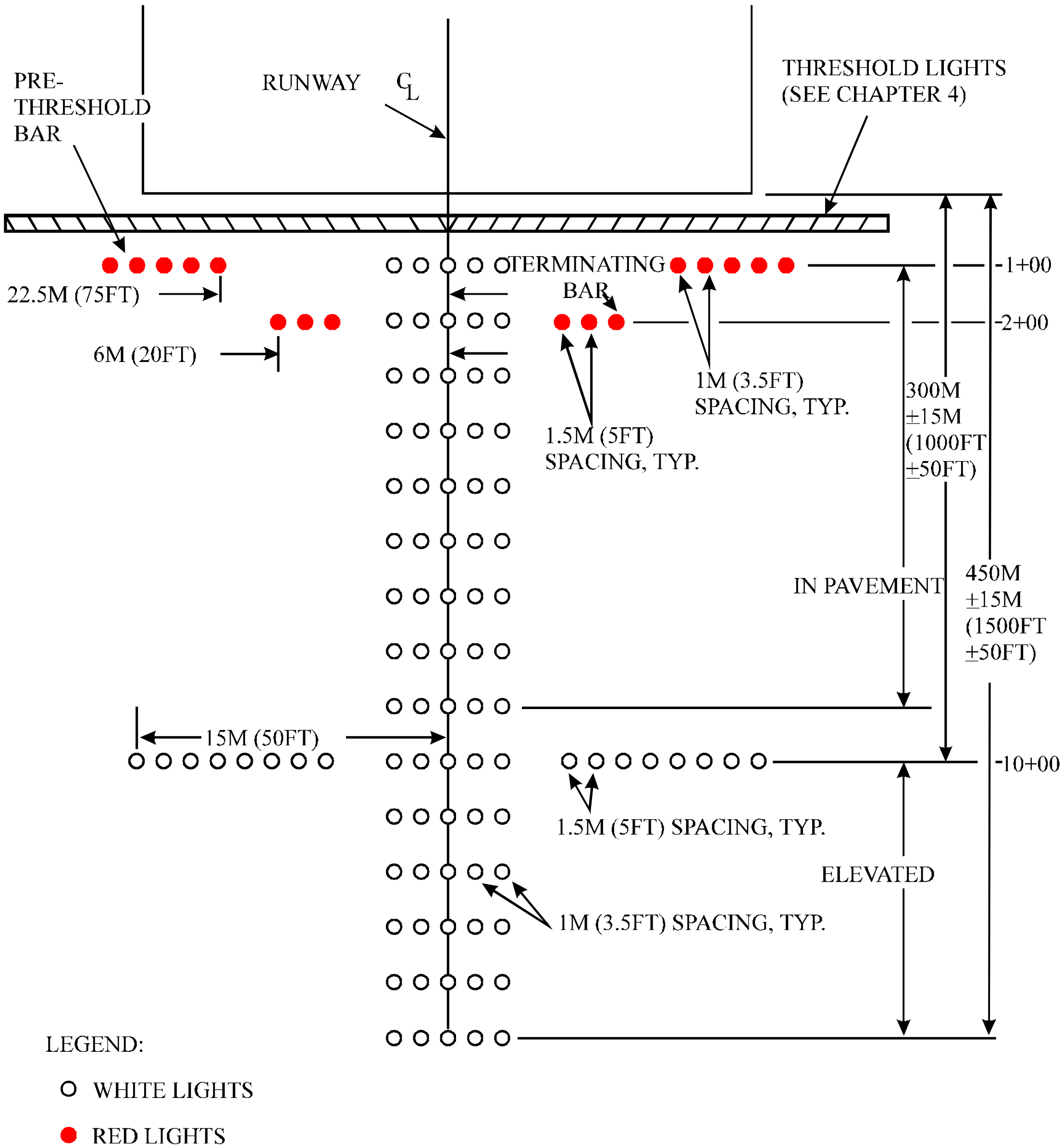
3.2.6. Control Requirements. The control requirements in paragraph 3.1.6 for ALSF-1 systems apply.
3.2.7. Monitoring Requirements. Provide monitoring which, at a minimum, gives a positive indication at a control facility that power is being provided to the system.
3.2.8. Equipment. See Chapter 12, paragraph 12.9.1; fixtures and supports for ALSF-1 apply.
3.2.9. Compliance with International Military Standards:
3.2.9.1. ASCC. This standard meets the requirements for a type C system as described in ASCC AIR STD 65/35 Aerodrome Lighting.
3.2.9.2. NATO. This standard meets the requirements for a type II system as described in NATO STANAG 3316, Airfield Lighting, except for the vertical aiming of the lights.

3.3. Short Approach Lighting System (SALS):

3.3.1. Purpose. The SALS is a high intensity approach light system used at locations where installation space is a problem and non-precision approaches are conducted. This configuration requires a waiver. See paragraph 1.8, Waivers of Requirement.

3.3.2. Configuration. The SALS, as shown in figure 3.8, is configured as an ALSF-1, except the system is 450 meters (1,500 feet) long and does not have sequenced flashing lights.

Figure 3.8. SALS Configuration.



3.3.3. Photometrics. The requirements in paragraph 3.1.4 for ALSF-1 apply.

3.3.4. Power, Control and Monitoring. The requirements in paragraphs 3.1.5 through 3.1.7 for the ALSF-1 system apply. See figure 3.1 for the system block diagram.

3.3.5. Equipment Used. See Chapter 12, paragraph 12.9.1 (ALSF-1), for applicable components.

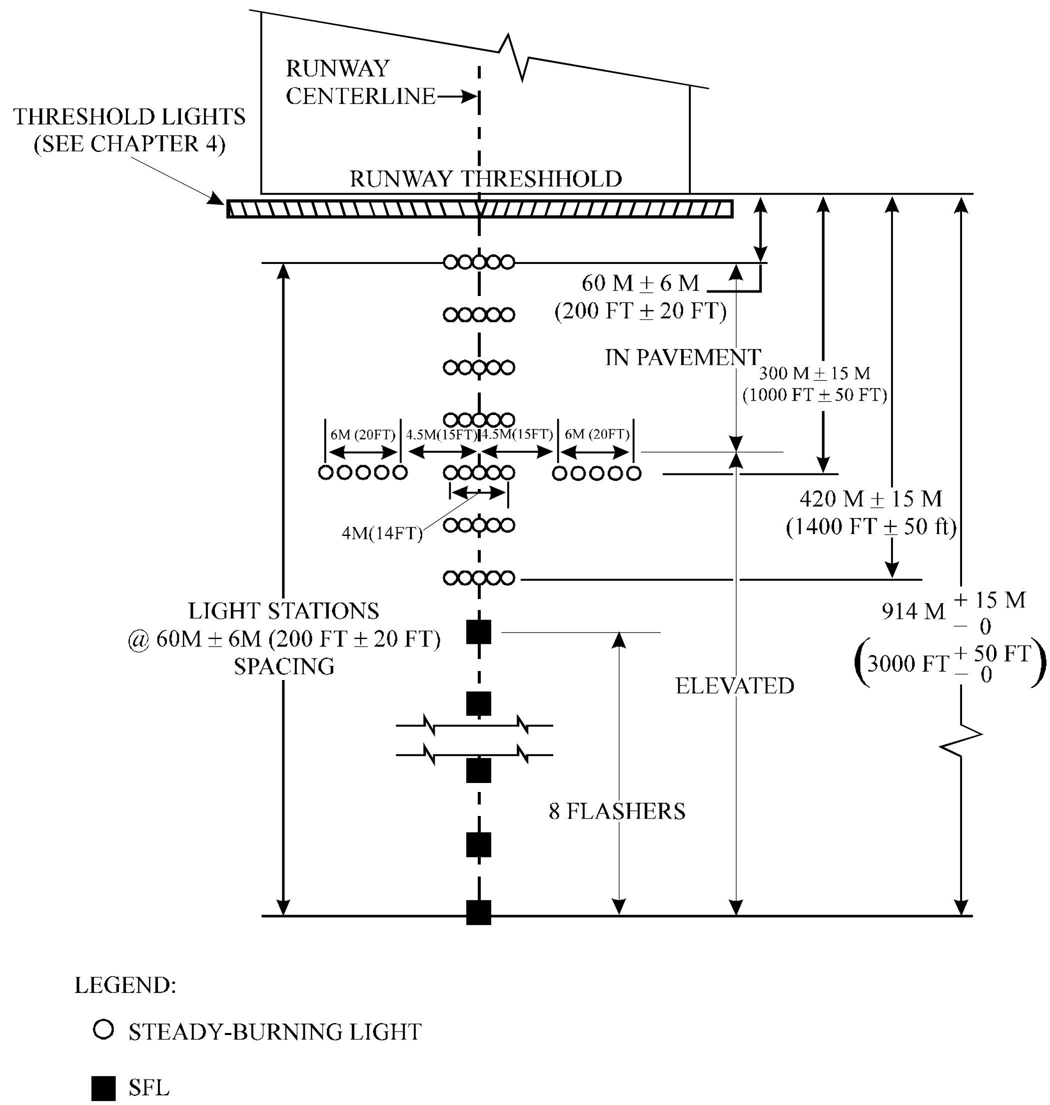
3.3.6. Compliance with International Standards. There are no equivalent systems in the ASCC or NATO standards.

3.4. Simplified Short Approach Lighting System with Runway Alignment Indicator Lights (SSALR):

3.4.1. Purpose. The SSALR is a simplified version of the ALSF-1 or ALSF-2. This system configuration is normally achieved by electrically switching off elements of an ALSF-1 or ALSF-2 for energy conservation purposes, when weather conditions permit. This configuration requires a waiver. See paragraph 1.8, Waivers of Requirement.

3.4.2. Configuration. The SSALR, shown in figure 3.9, is configured as an ALSF-1, except that the outer 480 meters (1,600 feet) of the steady burning lights are inoperative as are the odd numbered light stations on the inner 300 meters (1,400 feet), the outer three lights at each end of the 1,000-foot bar, and the red lights in the terminating and pre-threshold bars. Also, the sequenced flashing lights are inoperative at stations 10+00 through 15+00 and at the odd numbered stations thereafter.

Figure 3.9. SSALR Configuration.



3.4.3. Other Requirements. All other requirements in paragraph 3.1 for ALSF-1 apply.

3.4.4. Compliance with International Standards. There are no equivalent systems in the ASCC or NATO standards.

3.5. Medium Intensity Approach Light System with Runway Alignment Indicator Lights (MALSR):

3.5.1. Purpose. The MALSR is a medium intensity approach light system with sequenced flashing lights used for runway alignment. This system provides visual approach area identification, centerline alignment, and roll reference for aircraft making approaches for landings during day or night operations. This configuration is FAA approved for ILS CAT I approaches, but requires a waiver for US Air Force use. See paragraph 1.8, Waivers of Requirement.

3.5.2. Associated Systems. In addition to electronic aids, such as ILS, which provide electronic guidance down to a minimum of not less than 60 meters (200 feet) CAT I condition the MALSR should include the following:

3.5.2.1. Non-precision or precision approach instrument runway markings.

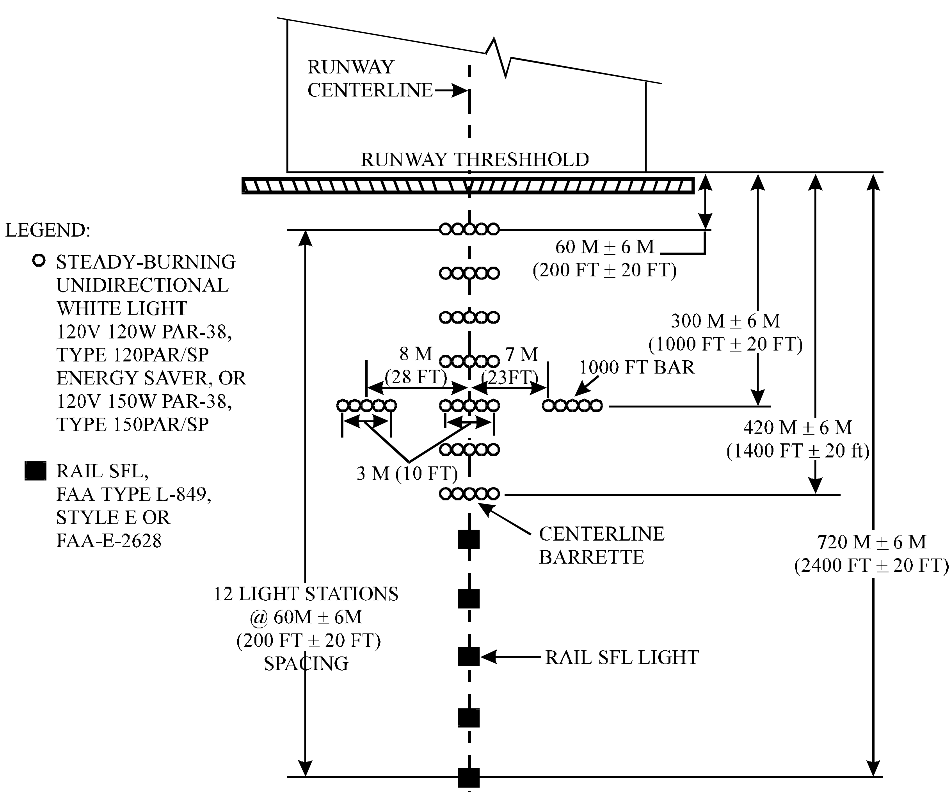
3.5.2.2. High-intensity Runway edge Lights (HIRL).

3.5.2.3. Threshold lights or displaced threshold lights.

3.5.2.4. Precision Approach Path Indicator (PAPI).

3.5.3. Configuration. The MALSR is a system of light bars, barrettes, and Sequenced Flashing Lights (SFL) in the approach zone immediately ahead of the runway threshold. The preferred length of a MALSR is 720 meters (2,400 feet), but may be shortened to not less than 460 meters (1,380 feet) where space or impractical construction problems exist. The plan of the MALSR is shown in figure 3.10 and the schedule of lighting equipment is given in Chapter 12. The MALSR consists of centerline light barrettes, 300 meters (1,000 feet) crossbar, and the Runway Alignment Indicator Lights (RAIL), or sequenced flashing lights. In the MALSR, a barrette is three or more lights closely spaced in a transverse line for which the length shall not exceed 5 meters (15 feet) and the center-to-center spacing of the lights shall not exceed 1.5 meters (5 feet).

Figure 3.10. MALSR Configuration.



3.5.3.1. Centerline Light Barrettes. The centerline lights consist of seven 5-light barrettes of steady-burning, uni-directional, white, elevated lights. For runways with displaced thresholds or paved overruns, the centerline lights on the runway and overrun shall be in pavement lights. Normal configuration is 60 meters (200 feet) spacing starting 60 meters (200 feet) from the threshold and extending to 420 meters (1,400 feet).

3.5.3.2. 1,000-Foot Crossbar. The crossbar is 300 meters (1,000 feet) from the runway threshold and consists of three 5-light barrettes of steady-burning, uni-directional, white, elevated lights. For runways with displaced thresholds or paved overruns, the centerline lights on the runway and overrun shall be in pavement lights.

3.5.3.3. Runway Alignment Indicator Lights (RAIL). The RAIL consists of five single Sequenced Flashing Lights (SFL) on the runway centerline in the approach area of the centerline barrette lights. These lights are capacitor-discharge, uni-directional, white, elevated lights which are flashed in sequence from the approach end towards the runway thresholds. Preferably the SFLs shall be located between 480 meters and 800 meters (1,600 feet and 2,400 feet) from the runway threshold, spaced at 60 meters (200 feet) apart. If the length of the MALSR is less than 720 meters (2,400 feet), for each SFL deleted at the beginning of the RAIL a SFL may be placed progressively at a centerline barrette until the 1,000-foot crossbar is reached. If the total length of the MALSR is less than 600 meters (1,800 feet) reduce the number of SFL used. **NOTE:** Do not use less than three SFL which may be located at the three outer centerline barrettes.

3.5.3.4. Threshold Lights. The MALSR does not require special threshold lights. The runway threshold lights provide adequate lights for marking the threshold.

3.5.4. Photometrics. The color of the steady-burning lights shall be aviation white for the centerline and 300 meters (1,000 feet) crossbar lights. The color of SFL may be aviation white or bluish-white similar to xenon gas discharge lights. The intensity steps based on rated intensity shall be 100 percent for high setting, 20 percent for medium setting, and 4 percent for low setting for the steady burning centerline and 30 meters (100 feet) crossbar lights and 100 percent for high setting, 10 percent for medium setting, and 2 percent for low setting for the SFL. The SFL shall flash in sequence from the outer end toward the runway threshold at a steady rate between 60 and 120 times per minute. The interval between flashes of adjacent lights shall nominally be 1/30 seconds. The intensity-distribution of the lights shall be as follows:

3.5.4.1. Steady-burning white lights. The peak intensity for the elevated lights at the rated 120 volts shall be not less than 10,000 candelas and the intensity shall be not less than 1,000 candelas at any angle up to 15 degrees from the beam axis. For the in pavement lights, the peak intensity shall be not less than 10,000 candelas with the beam spread from the beam axis at 2500 candelas not less than +/- 5 degrees horizontally and +/- 3.5 degrees vertically and at 500 candelas not less than +/- 7 degrees horizontally and +/- 5.5 degrees vertically.

3.5.4.2. Sequenced Flashing Lights (SFL). The rated effective intensity shall be not less than 7,500 candelas or more than 22,500 candelas for 15 degrees horizontally and 5 degrees vertically from the beam axis.

3.5.5. Aiming Criteria. The beams of all approach lights shall be aimed into the approach zone and away from the threshold with the axis of the beams parallel in azimuth to the extended runway centerline. The vertical aiming of the elevated lights shall be in accordance with the table 3.2. The in pavement lights have fixed elevation angles for the beams, and only require that the light base flange be level.

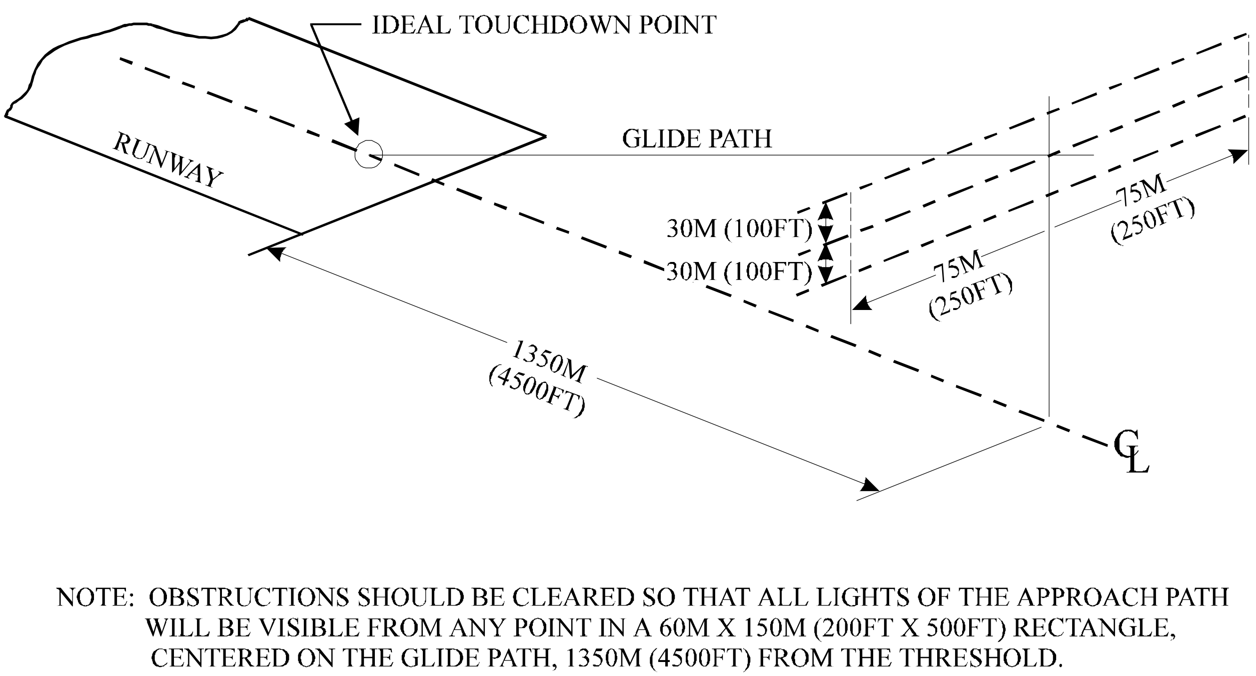
Table 3.2. Elevation Setting Angles for MALSR.

ELEVATED UNI-DIRECTIONAL LIGHTS Steady-Burning Lights					
Station	**Setting Angle above Horizontal (Degrees)**		**Station**	**Setting Angle above Horizontal (Degrees)**	
	Preferred	**Permitted**		**Preferred**	**Permitted**
14+00	3.7	3.5	6+00	3.4	3.5
12+00	3.6	3.5	4+00	3.3	3.5
10+00	3.5	3.5	2+00	3.2	3.0
8+00	3.4	3.5			
Elevated SFL are all aimed 6 degrees above horizontal.					

3.5.5.1. Approach Planes. The following restrictions apply for a MALSR installation:

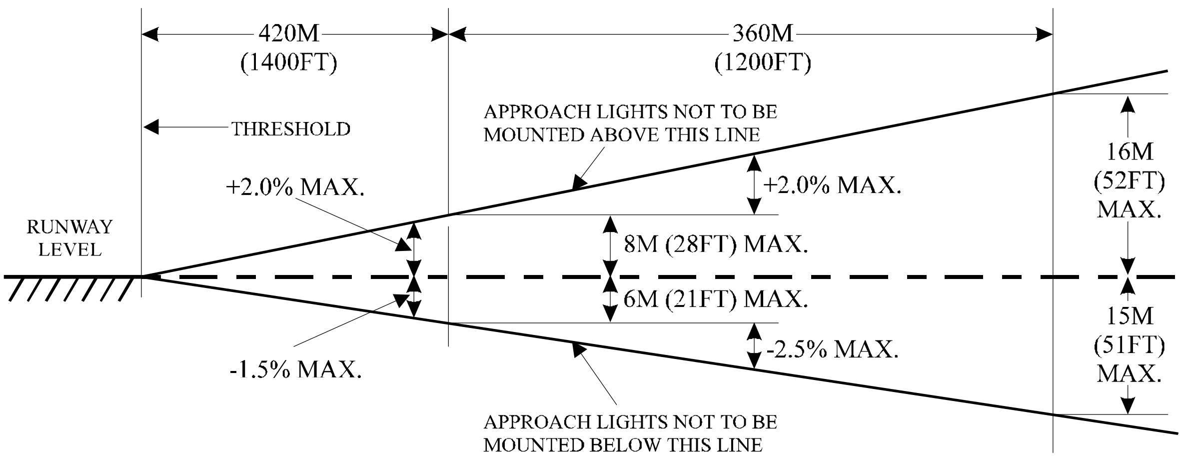
- No object will be permitted to obstruct the visibility of any approach light from the viewing window. The viewing window is a rectangular area 30 meters (100 feet) above and below and 75 meters (250 feet) left and right of the ideal glide path at 1,350 meters (4,500 feet) before the runway threshold. (See figure 3.11).

Figure 3.11. Viewing Window for MALSR.



- The approach light plane, see figure 3.12, is an area 120 meters (400 feet) wide centered on the extended runway centerline which begins at the runway threshold and extends 60 meters (200 feet) beyond the outermost light in which the approach light centers are located. All lines in the planes perpendicular to the runway centerline are horizontal. Ideally, all the lights will be installed in a single horizontal plane at the same elevation as the runway threshold without any penetrations by fixed solid objects. Where deviations are necessary for terrain or objects which cannot be removed, the sections starting from the first approach light station from the threshold shall have a minimum slope which shall not exceed +2.0 percent upward or -1.0 percent downward for the steady-burning barrette lights. For the RAIL section, the slope of the light planes shall not exceed +2.0 percent or -2.5 percent. Any sloping or horizontal plane shall contain not less than three light stations.

Figure 3.12. Light Plane Elevation Limits.



NOTE: THE BOUNDARIES OF THE LIGHT PLANES ARE THE RUNWAY THRESHOLD, 60M (200FT) AHEAD OF THE END LIGHT STATION, AND 60M (200FT) EACH SIDE OF CENTERLINE.

- No objects, except the elevated light of the MALSR in the end zone, should be permitted to extend above the light planes within the boundaries. Objects that extend 7.5 meters (23 feet) above all railroads are considered as obstructions. Objects that extend 6 meters (17 feet) above the highest point of the road surface of interstate highways are considered as obstructions. Objects that extend 5 meters (15 feet) above extend above other highways, public roads, and parking areas are considered as obstructions. Private or military roads are considered as objects 3 meters (10 feet) or higher except for airport service roads where vehicular traffic is controlled by the control tower or have signs requiring traffic to stop and visually check for aircraft before proceeding and prohibiting parking or stopping between signs.
- Every effort must be made to remove or relocate objects which penetrate the light plane. For objects which cannot be moved, the height must keep to a minimum and shall be located as far from the threshold as possible.
- For objects which are not feasible to remove, lower, or relocate and cannot be cleared by the positive slope, MAJCOM permission may be granted to exceed the two percent slope for that light plane.

3.5.6. Tolerance. The tolerances for positioning steady burning MALSR lights are as follows:

- Lateral tolerance of a bar is 0.15 meters (6 inches).
- Distance between individual light centers in a barrette is 0.05 meters (2 inches).
- Height for light centers up to 1.8 meters (6 feet) is 0.05 meters (2 inches).
- Height for light centers over 12 meters (40 feet) is 0.15 meters (6 inches).
- Tolerance for vertical aiming of light units is 1.0 degree.
- Tolerance for horizontal aiming of light unit is 5 degrees.

- Longitudinal deviation for light bars or single SFL from a designated station is 6 meters (20 feet), except light stations may be displaced 30 meters (100 feet) to avoid omitting a light station where obstructions cannot be removed or cleared by acceptable clearance planes. Where a light station must be located more than 6 meters (20 feet) from the usual station, position the nearby light stations to provide more uniform spacing between lights.

3.5.7. Power Requirements. The electrical power for the MALSR approach lights shall be as follows:

3.5.7.1. For the centerline and 300 meters (1,000 feet) crossbar steady-burning lights, a special power unit shall furnish power to these lights from a multiple circuit rated at 120 volts or 120/240 volts 3-wire. This power unit shall energize the lights at either of the three intensive settings as selected.

3.5.7.2. For the SFL, the power to operate these lights shall be 120 volts furnished by the master control unit. These lights have individual power supply units which may be combined with or separated from the flasher head. Allow an additional 5 KVA of transformer capacity for the SFL. **NOTE:** Emergency power is not essential for the MALSR system, but if emergency power is available, it should be used with the automatic emergency power transfer.

3.5.8. Control Requirements. The MALSR shall be remotely controlled from the airfield lighting control panel in the control tower. Alternate control from the airfield lighting vault is desirable. A separate control shall provide for switching ON and OFF and for selecting the intensity setting of the centerline lights, the 300 meters (1,000 feet) bar lights, and the SFL.

3.5.9. Monitoring Requirements. The operation of the MALSR system, including the intensity selection, should be visually observed at least once each day. Automatic monitoring is not required, but it may be used if the equipment installed has this capability.

3.5.10. Equipment. See Chapter 12, paragraphs 12.9.5 through 12.9.5.4 for typical MALSR components.

3.5.10.1. Fixtures and Components. The lighting equipment for the MALSR is shown in Chapter 12. Typical elevated steady-burning lights for the centerline lights and 300 meters (1,000 feet) bar lights are shown in the figures. Each SFL shall consist of a flasher head and a power supply unit. The flasher head and power supply unit may be combined to install at any distance of not more than 45 meters (150 feet) from the power supply unit.

3.5.10.2. Light Supports. The type of supports for the MALSR lights depends on the height of the light or barrette above the surface as follows:

- Elevated light heights 2 meters (6 feet) or less use frangible supports.
- Light heights between 2 meters (6 feet) and 13 meters (40 feet) use low-impact-resistant supports. The individual SFL or 5-light barrettes shall be installed on low-impact-resistant supports of the correct height. These supports may be non-metallic, FAA-E-2702 supports or triangular, antenna support type, FAA AC 150/5345-45.
- Light heights more than 12 meters (40 feet) should use semi-frangible supports. Individual SFL or 5-light barrettes shall have the top 6 meters (20 feet) of the support of the low-impact-resistant type installed on a rigid support of the correct height.

3.5.10.3. Mounting the Lights. In pavement lights should be used only in displaced threshold areas or paved overruns. These in pavement lights shall be mounted on corrosion-proof steel light bases set in a concrete foundation. These lights may project not more than 0.025 meters (1 inch) above the paved surface. The elevated lights are mounted at the correct height on frangible, low-impact-resistant, or semi-frangible supports. Frangible supports are used for heights of 2 meters (6 feet) or less. The support consists of a frangible coupling and sections of 0.05 meters (2 inch) diameter conduit elbows set in concrete foundation. For heights more than 2 meters (6 feet), the barrettes or individual SFL shall be placed on low impact-resistant or semi-frangible supports.

3.5.11. Compliance with International Standards.

3.5.11.1. There are no equivalent ASCC or NATO standards for this system, however, it does meet the requirements for a Cat I approach approved by the FAA.

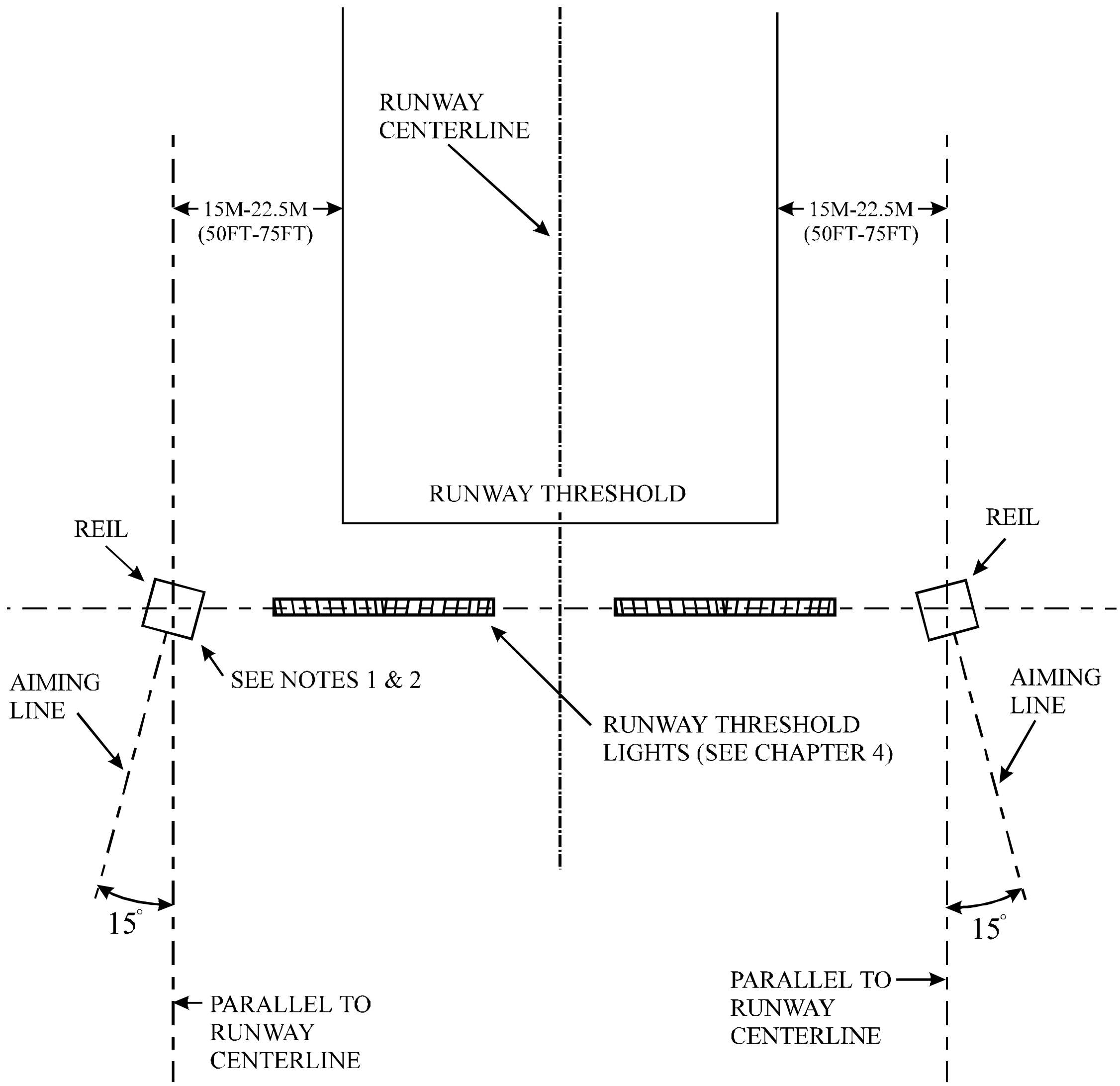
3.6. Runway End Identifier Lights (REIL):

3.6.1. Purpose. The REIL is to provide the pilot with rapid and positive identification of the runway threshold during approach for landing. The REIL assists the pilot in making landings in VFR conditions and in non-precision instrument approaches in Instrument Flight Rules (IFR) conditions.

3.6.2. Associated Systems. The following visual aids are required with the use of the REIL: High intensity runway edge lights, runway threshold lights or displaced threshold lights, and runway markings. The PAPI system may also be an associated visual aid.

3.6.3. Configuration/Location/Aiming. A REIL system as shown in figure 3.13, consists of synchronized flashing lights, placed symmetrically about the runway centerline in the vicinity of the runway threshold. The optimum location is 15 meters (50 feet) from the runway edge and in line with the threshold lights. The lights may be located laterally up to 22.5 meters (75 feet) from the runway edge and longitudinally up to 15 meters (50 feet) downwind (away from the runway) from the threshold lights. Adjust the location of both lights as equally as possible to maintain the symmetry of the installation. The difference in locations shall not be more than 3 meters (10 feet) laterally or longitudinally. The elevation of both lights shall be within 3 meters (10 feet) of the runway centerline at the threshold. Do not install REILs on runways served by Pulsed Light Approach Slope Indicators (PLASI).

Figure 3.13. REIL Configuration.



NOTES:

1. LONGITUDINAL LOCATION OF REIL FIXTURES MAY BE VARIED FROM IN LINE WITH THRESHOLD TO 15M (50FT) DOWNWIND OF THRESHOLD. BOTH FIXTURES WILL BE AT THE SAME DISTANCE.

2. UNIDIRECTIONAL FIXTURE IS ILLUSTRATED, FOR OMNIDIRECTIONAL FIXTURE IGNORE HORIZONTAL AIMING.

3.6.4. Photometric Requirements:

3.6.4.1. Uni-directional Fixtures. The requirements for sequenced flashing lights apply.

3.6.4.2. Omni-Directional Fixtures. Omni-directional fixtures shall flash at a rate of once per second, producing a white light through 360 degrees horizontally and vertically from +2 degrees to +10 degrees above the horizontal. Light units shall be capable of being shielded when required by local conditions. Mount REIL fixtures on frangible supports. The unit shall be capable of operating at three intensities:

Step 1 @ 700 +/- 280 cd
Step 2 @ 1,500 +/- 600 cd
Step 3 @ 5,000 +/- 2,000 cd

3.6.5. Power Requirements. The system may be powered separately or use of a power adapter unit connected to the runway light circuit. There is no requirement for standby power.

3.6.6. Control Requirements. REIL systems may be controlled separately or coupled to the associated runway edge light circuit through current sensing relays or other devices. When coupled to the runway edge lights, they should operate as follows:

Edge Light Intensity	REIL Intensity
Off	Off
Step 1 or 2	Low
Step 3	Medium
Step 4 or 5	High

3.6.7. Monitoring Requirements. There are no monitoring requirements required for the REIL system.

3.6.8. Compliance with International Standards.

3.6.8.1. NATO. The uni-directional flashing lights meet the requirements of NATO STANAG 3316, Airfield Lighting, except for the displacement distance from the runway edge and the aiming angle.

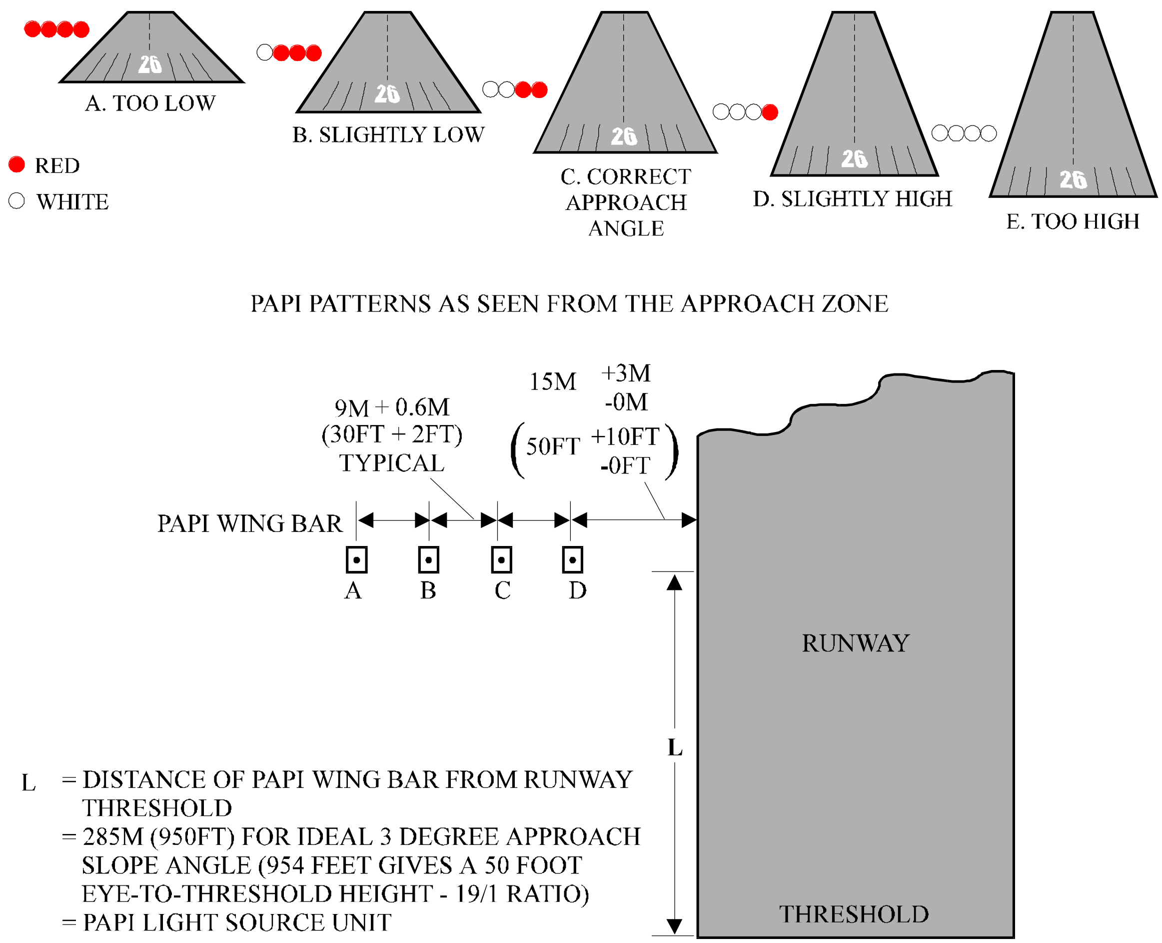
3.6.8.2. ASCC. This system meets the requirements of AIR STD 65/35, except for the distance from the runway edge and the aiming angles.

3.7. Precision Approach Path Indicator (PAPI) System:

3.7.1. Purpose. The PAPI is an unattended system which provides visual glide path guidance for landing an aircraft.

3.7.2. Configuration. The US Air Force standard PAPI system consists of a light bar with four light units (FAA L-880, per AC 150/5345-28) placed on the left side of the runway in the vicinity of the touchdown point. (See figure 3.14).

Figure 3.14. PAPI Configuration.



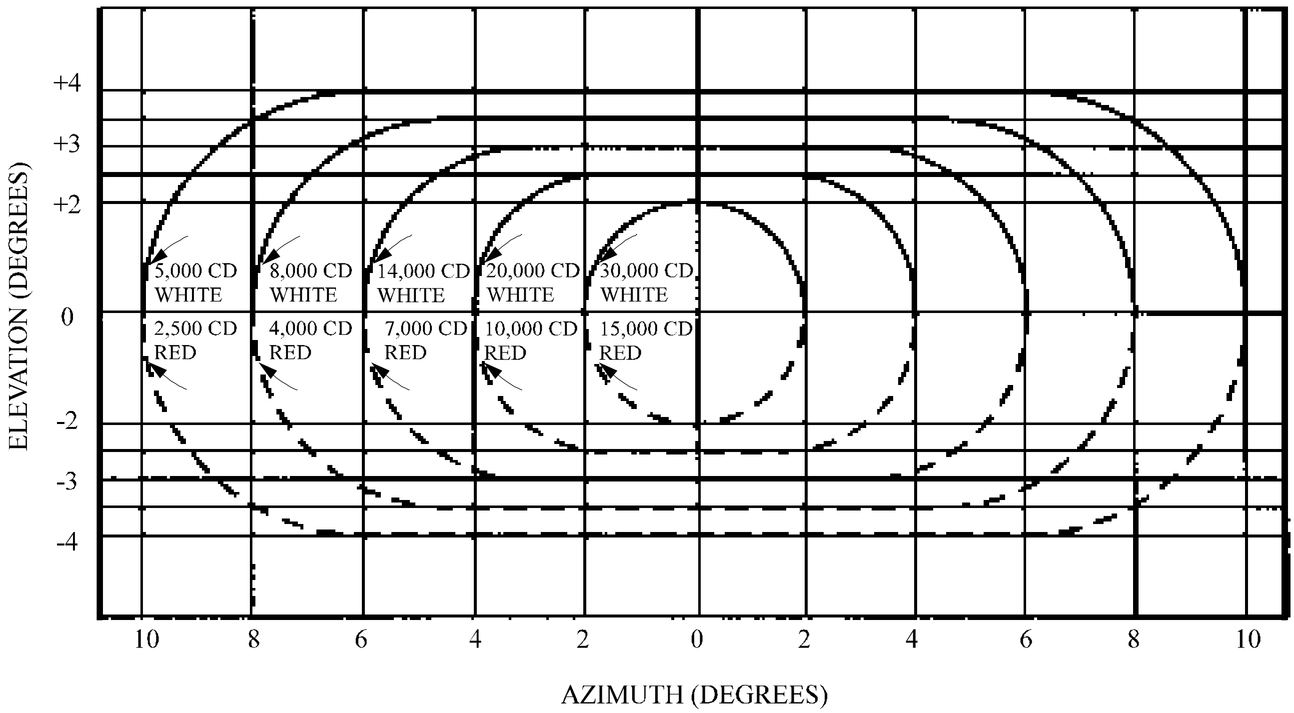
3.7.2.1. Each light unit shall be frangible mounted. It shall contain two lamps minimum, with 3 lamps preferred, and an optical system that produces a horizontally split, two color (white over red) light beam.

3.7.2.2. Beginning at the out-board-most units, each unit in a bar is aimed into the approach at a successively higher angle above the horizontal. When on a proper approach path, the pilot sees the two inboard lights in both bars as red and the two outboard lights as white. As the approaching aircraft settles below the proper path, the pilot sees an increasing number of red lights in each bar. As the aircraft rises above the path, the pilot sees an increasing number of white lights. (See figure 3.14).

3.7.2.3. The centerline of the innermost unit in each bar shall be no closer than 15 meters (50 feet) from the runway edge, and the units in a bar shall be 9 meters (30 feet) on centers. The beam centers of all light units shall be within +/- 0.025 meters (1 inch) of a horizontal plane. This horizontal plane shall be within +/- 0.30 meters (1 foot) of the elevation of the runway centerline at the intercept point of the visual glidepath with the runway. The units in a bar shall all be within 0.025 meters (1 inch) of a line drawn perpendicular to the runway centerline. The distance from threshold to the PAPI should be the shortest distance that will accommodate the criteria contained in paragraph 3.7.4.2 below.

3.7.3. Photometric Requirements. PAPI light units shall be capable of satisfying the intensity requirements given in figure 3.15 at the maximum intensity setting.

Figure 3.15. PAPI Photometric Requirements.



3.7.3.1. PAPI systems shall be capable of operating at five intensity settings as follows:

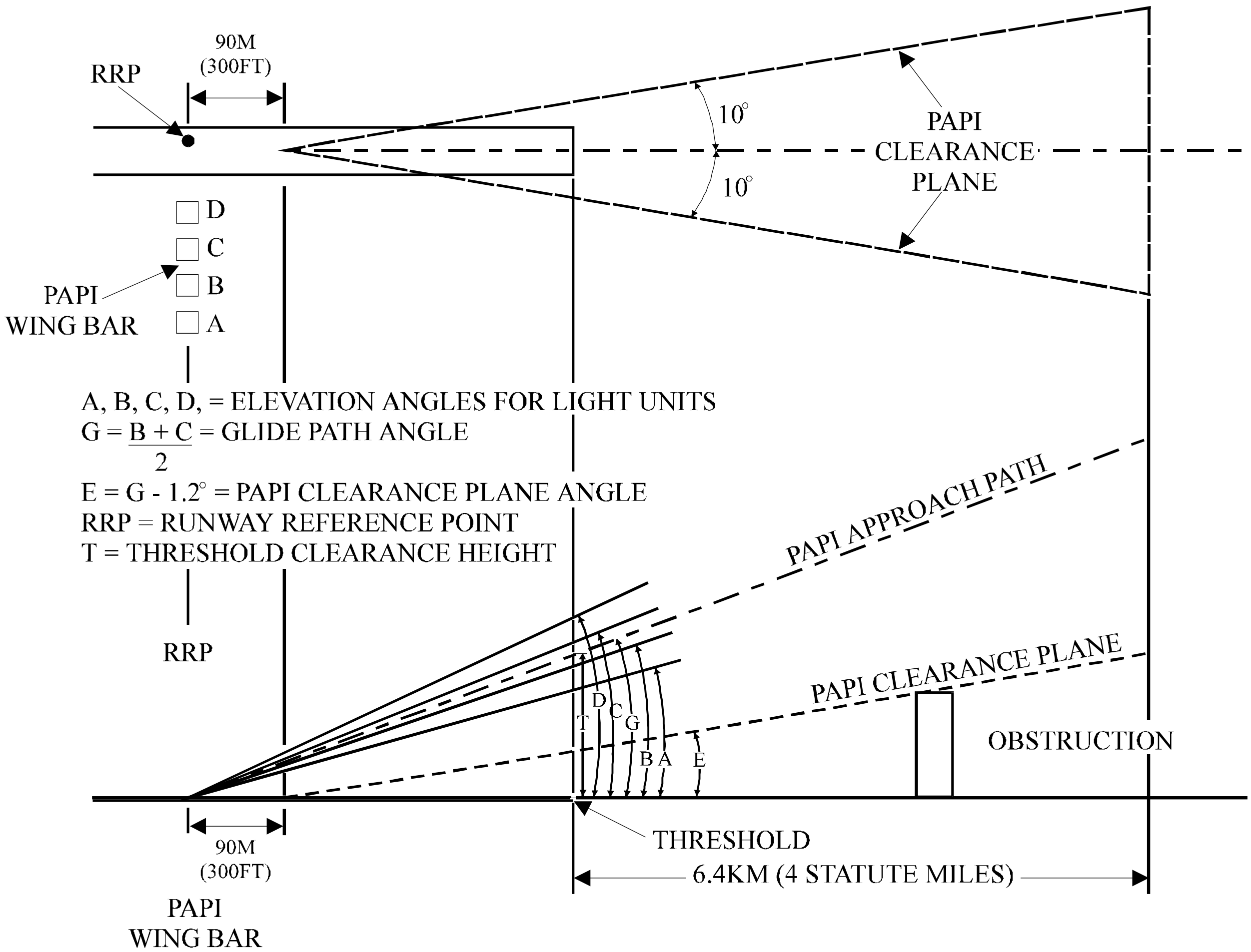
Step	Percentage of Full Intensity
*1	0.16
2	0.8
3	4.0
4	20.0
5	100.0

*The Step 1 setting may not be sufficient to heat the lamp filaments adequately and provide proper color definition. Where this is a problem, consult the manufacturer on how to bypass this setting.

3.7.3.2. Aim PAPI units parallel with the approach within 0.5 degrees. Aim successive light units in a light bar vertically, beginning with the out-board-most unit, incrementally at increasingly higher angles. The glide path angle is the mean of the highest and lowest angle setting. (See figure 3.16). Set the angular difference between successive light units as follows:

Approach Angle	Angular Difference
2 to 4 degrees	20 minutes
over 4 to 7 degrees	30 minutes
over 7 degrees	1 degree

Figure 3.16. PAPI Aiming Criteria.



3.7.3.3. System Aiming Criteria. The location and alignment of the PAPI may be varied to meet local conditions so long as the effective glide path is not less than 2.5 degrees nor more than 4.0 degrees above the horizontal. Unless otherwise directed and where conditions permit, the design glide path angle shall be 3.0 degrees. For design purposes, the visual glide path is considered to begin at the PAPI Runway Reference Point (RRP), a point on the runway centerline at the PAPI light bar, and project into the approach at the glide path angle. (See figure 3.16). On a precision instrument runway, aim the PAPI at the same angle as the electronic glide path. This procedure shall be modified for runways that serve aircraft in height group 4 (table 3.3), for these runways the distance of the PAPI from the threshold shall equal the distance to the electronic glide slope source plus an additional 300 feet.

3.7.4. Consider the following conditions and adjustments when siting a PAPI:

3.7.4.1. Before electing to install a PAPI on a runway with a precision instrument approach, note that the vertical course width of a PAPI is extremely narrow when compared to an ILS glide path. There may be a high incidence of “above path” or below path indications when transitioning from the instrument portion to the visual portion of the approach and system confidence may be affected. If this occurs, it may be necessary to turn the PAPI off during instrument operations.

3.7.4.2. The optimal PAPI system described in paragraph 3.7.2 and installed at 285 meters (950 feet) will produce a 10.5 meters (35 feet) wheel clearance at the threshold for an aircraft with an “eye to wheel” height of 4.5 meters (15 feet) and where the threshold is at the same elevation as the RRP. [A 15 meters (50 feet) Threshold Crossing Height (TCH) at 3 degrees gives a 954 feet RRP]. [This is about a 19/1 ratio, therefore for every additional 1 meter (3 feet) TCH required, the RRP will increase by 19 meters

(63.3 feet)]. At locations where the glide path angle is decreased, the threshold elevation is significantly higher than the RRP elevation, or the "eye to wheel" height of the critical aircraft is significantly greater than 4.5 meters (15 feet), adjust the location of the RRP to provide a threshold crossing height as close to the optimum as the available runway length will allow. Less than optimal wheel clearances are permitted but in no case shall the wheel clearance be less than 9 meters (30 feet). With higher approach angles, or where the threshold is at a lower elevation than the RRP, move the system downwind from the theoretical optimum to maximize the runway length available for rollout. See table 3.3 for additional guidance.

Table 3.3. Visual Threshold Crossing Height Groups.

Height Group	Approximate Cockpit-to-Wheel Height	Visual Threshold Crossing Height
#1. Gen. Aviation, Small Commuters, Corporate Turbojets, T-37, T-38, C-21, T-1, C-12, C-20 Fighter Jets	3 m (10 ft) or less	10 m (40 ft)
#2. F-28, CV-340/440/580, B-737, DC-9, DC-8, C-9, T43, C130, B-2	4.5 m (15 ft)	12 m (45 ft)
#3. B-727/707/720/757, KC-135, C-141, C-17, B-52	6 m (20 ft)	15 m (50 ft)
#4. B747/767, L-1011, DC-10, A300, KC-10, C-5, VC-25	Over 7.5 m (25 ft)	22 m (75 ft)
Refer to FAA AC 150/5345-28 for additional information.		

3.7.4.3. No light unit shall be closer than 15 meters (50 feet) to any other runway, taxiway, or apron. Avoid locations where the system could be obscured by other installations. Do not place other lights so close to the PAPI as to cause pilot confusion. Where these conditions cannot readily be satisfied with the system located on the left side of the runway, the system may, with MAJCOM waiver approval, be sited on the right side of the runway.

3.7.4.4. In areas that experience large accumulations of snow the mounting height may be increased but the overall height of the unit shall not exceed 2 meters (6 feet) above the ground. The bars may be relocated downwind to compensate for the extra height above the runway centerline elevation, but still remain in the glideslope plane.

3.7.4.5. Establish a PAPI clearance plane referenced to a point 90 meters (300 feet) downwind of the PAPI RRP which clears all obstructions in the approach zone. The aiming angle for the PAPI glide path shall be not less than 1.2 degrees above the PAPI clearance plane. A plan view of the PAPI clearance plane is a triangle which begins at a point on the runway centerline 90 meters (300 feet) downwind from the PAPI RRP and diverges outward into the approach at 10 degrees on either side of the extended runway centerline for a distance of 6.44 kilometers (4 statue miles) from the threshold. (See figure 3.16). Where the sides of the plane do not encompass the runway width at the threshold, the width at that point shall be increased to the runway width while maintaining the 10 degree angle of divergence.

3.7.5. Power Requirements. The electrical power for the PAPI system shall be from a separate 120/240 volt circuit or a 6.6A series circuit. The circuit shall be energized by a constant-current regulator. This regulator should be 4 kW with five intensity steps. The lights shall be connected to the series circuit by series isolation transformers of suitable capacity for each lamp. Emergency power is not essential but it should be used if available. The emergency transfer of power should be the same as the runway edge lights. Monitoring of the PAPI is not required except for daily visual checks of operations.

3.7.6. Control Requirements. The controls for the PAPI shall be by remote manual control from the Air Traffic Control tower with alternate control from the airfield lighting vault. Both the power on/off control and, as an option, the 5-step intensity control may also be at the airfield lighting control panel. The intensities shall be 100, 20, 4, 0.8, and 0.2 percent of rated intensity corresponding to intensity steps 5, 4, 3, 2, and 1. If it is not practical to provide remote control, the PAPI may be automatically controlled by a photoelectric switch with power from a local source instead of the vault. For automatic control the PAPI is at 20 percent intensity (step 4 preferred) or 100 percent intensity (step 5) during the daytime and 4 percent intensity (step 3) at night. The PAPI should operate at night only when the runway edge lights are operating.

3.7.7. Equipment. See Chapter 12, paragraph 12.9.7, for applicable PAPI system fixtures. See FAA AC 150/5345-28, latest issue for additional information.

3.7.8. Flight Inspections. Refer to AFMAN 11-225 United States Standard Flight Inspection Manual for flight inspection requirements (commissioning flight) prior to use.

3.7.9. Compliance with International Standards.

3.7.9.1. NATO. This PAPI criteria meets the requirements of NATO STANAG 3316 Airfield Lighting, except the Air Force system is located on only one runway side.

3.7.9.2. ASCC. This PAPI criteria meets the requirements of ASCC AIR STD 65/35.

Chapter 4

STANDARDS FOR RUNWAY LIGHTING SYSTEMS

4.1. General Description:

4.1.1. Visual Flight Rules (VFR) Runway Perimeter Lighting. Runway edge lights, threshold lights, and runway end lights are used to outline the lateral and longitudinal limits of the usable surface of the runway. They are required for VFR night operation and for all categories of instrument operations.

4.1.2. Instrument Flight Rules (IFR). When Category II or III instrument operations are necessary, the perimeter lighting is augmented with touchdown zone and centerline lighting installed in the runway surface.

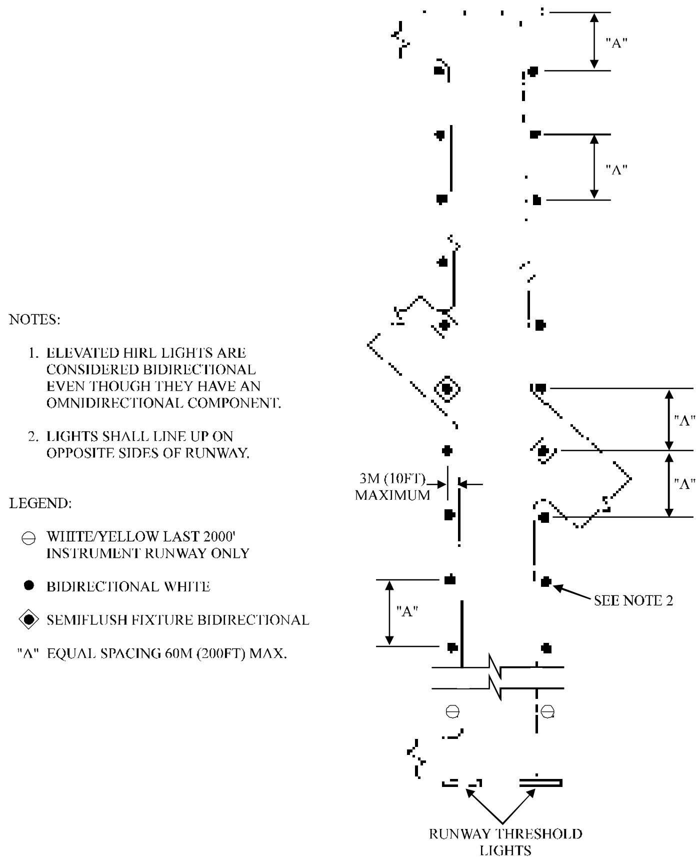
4.1.3. Runway Visual Aid Requirements. See table 2.1 for a matrix of VLA required under various conditions in addition to paragraphs 4.1.1 and 4.1.2 above. Runway distance markers and arresting gear markers are installed at the sides of the runway to help determine the distance remaining to the end of the runway and to locate arresting gear pendant cables.

4.2. High Intensity Runway Edge Lights (HIRL):

4.2.1. Purpose. HIRLs provide visual guidance during takeoff and landing operations at night and under low visibility conditions. High intensity runway edge lights are required for Category I, II, and III instrument operations.

4.2.2. Configuration. Locate runway edge lights on both sides of the runway not more than 3 meters (10 feet) from the edge of the full strength paving designated for runway use. Both lines of lights shall be equidistant from the runway centerline. (See figure 4.1).

Figure 4.1. Runway Edge Light Configuration.



4.2.2.1. Light Spacing. Longitudinally, space the lights along the runway light lines at equal distances not exceeding 60 meters (200 feet). Determine the distance between lights by dividing the length of the runway light line between the threshold light lines into equal spaces approaching but not exceeding 60 meters (200 feet).

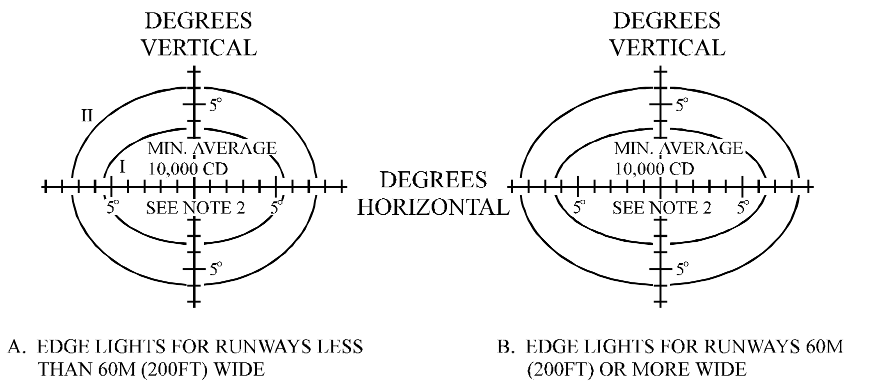
4.2.2.2. Use elevated lights in all instances except as noted below. Size the fixtures, light bases, and transformer housings to accept in pavement fixtures in the event of future runway configuration changes or modifications where elevated fixtures may not be suitable.

4.2.2.3. Use in pavement units in areas where elevated lights are subject to damage from jet blast, operation of an arresting barrier, or interference with aircraft operation. (See paragraph 12.10.1).

4.2.3. Photometric Requirements. Optimum aiming of lights depends on the design and output of the fixtures used in the system. Light fixtures may be designed to cover several applications and may have fixed patterns and aiming angles which differ from this manual. Light aiming and patterns other than those given in this manual may be used if the resultant light pattern produces equivalent light intensities in the areas required by this manual. High intensity runway edge lights shall be bi-directional. The lights shall be white, except that the last 600 meters (2,000 feet) on an instrument runway shall be yellow (in order to indicate a caution zone to the pilot) with minimum intensities of the main beams as shown in figure 4.2. They may be capable of providing small amounts of omni-directional light to provide circling guidance to the runway. The omni-directional component should be capable of being shielded during times of emergency. The main beams shall be toed in 3.5 degrees and elevated 4 degrees above the horizontal. Edge lights are operated at five intensity steps as follows:

Intensity Step	Light Intensity Percentage
1	0.16
2	0.80
3	4.00
4	20.00
5	100.00

Figure 4.2. Runway Edge Light Photometric Requirements.



A. Edge lights for runways less than 60M (200FT) wide

	I=50%	II=10%
a	5.5°	7.5°
b	3.5°	6.0°

B. Edge lights for runways 60M (200FT) or more wide

	I=50%	II=10%
a	6.5°	8.5°
b	3.5°	6.0°

NOTES:

1. ALL CONTOURS ARE ELLIPSES CALCULATED BY EQUATION $\frac{X^2}{a^2} + \frac{Y^2}{b^2} = 1$
2. THE MINIMUM AVERAGE INTENSITY OF THE MAIN BEAM (INSIDE CONTOUR I) IS 10,000 CD, AVIATION WHITE. MAXIMUM INTENSITY SHOULD NOT EXCEED 1.5 TIMES ACTUAL AVERAGE INTENSITY.
3. MINIMUM INTENSITY OF I=50% AND II=10% OF REQUIRED MAIN BEAM INTENSITY.

4.2.4. Equipment. Elevated fixtures shall be frangible mounted at a maximum of 0.35 meters (14 inches) above grade. At locations which experience frequent snow accumulations of 0.3 meters (12 inches) or more the mounting height may be increased to not more than 0.6 meters (24 inches) in height. No part of in pavement fixtures shall extend more than 0.025 meters (1 inch) above the surrounding surface. See Chapter 12, paragraph 12.10.1 for applicable fixtures.
4.2.5. Power Requirements. Provide a main and a standby power system with automatic transfer. Where used in support of Category II or III instrument operations, the transfer shall occur within 1 second of a failure of the system in use. For other operations, transfer shall occur within 15 seconds of the power failure.
4.2.6. Control Requirements. When used in support of instrument operations below 730 meters (2,400 feet) RVR, provide system monitoring which, at a minimum, gives positive indication at the control facility that power is being delivered to the system.
4.2.7. Compliance with International Military Standards:
4.2.7.1. NATO. These standards meet NATO STANAG 3316, Airfield Lighting.
4.2.7.2. ASCC. These standards meet the requirements of ASCC AIR STD 65/35 Aerodrome Lighting.
4.2.7.3. See FAA AC 150/5345-46 and AC 150/5340-24 for more information.

4.3. Medium Intensity Runway Edge Lights (MIRL):

4.3.1. Purpose. MIRLs are used on VFR runways, or runways having a non-precision Instrument Flight Rule procedure, for either circling or straight-in approaches. MIRLs are not installed on runways intended for precision approaches.

4.3.2. Configuration. The configuration shall be as specified in paragraph 4.2.2 for high intensity runway edge lighting.

4.3.3. Photometric Requirements. Optimum aiming of lights depends on the design and output of the fixtures used in the system. Light fixtures may be designed to cover several applications and may have fixed patterns and aiming angles which differ from this manual. Light aiming and patterns other than those given in this manual may be used if the resultant light pattern produces equivalent light intensities in the required areas. Medium intensity runway edge lights shall be omni-directional. Except as provided in paragraph 4.6 for displaced thresholds, which shall be yellow for the last 600 meters (2,000 feet), the lights shall be white with minimum intensities of the main beams as follows: from +2 degrees to +10 degrees vertically, 75 candelas minimum, 125 candelas average; from +10 degrees to +15 degrees vertically, 40 candelas minimum. Where semi-flush lights are required, they may be bi-directional. The edge lights shall be operated at 3 intensities as follows:

Intensity Step	Percent of full Intensity
1	10%
2	30%
3	100%

4.3.4. Equipment. Elevated fixtures shall be frangible mounted a maximum of .35 meters (14 inches) above grade. in pavement fixtures shall not protrude more than .025 meters (1 inch) above the surrounding surface. (See Chapter 12, paragraph 12.10.2). In areas of heavy snow, fixture height may be increased to a maximum of 0.6 meters (24 inches).

4.3.5. Power Requirements. Standby power is not required for medium intensity runway lights, except where they are installed on the primary runway. When installed on the primary runway, provide a main and a standby power system with automatic transfer within 15 seconds of failure of the system in use.

4.3.6. Control Requirements. Provide remote on and off and brightness control.

4.3.7. Monitoring. There is no requirement for monitoring.

4.3.8. Compliance with International Military Standards:

4.3.8.1. ASCC. This system meets ASCC AIR STD 65/35 Aerodrome Lighting for lighting of non-instrument runways.

4.3.8.2. NATO. This system does not meet NATO STANAG 3316, Airfield Lighting, for lighting of subsidiary runways.

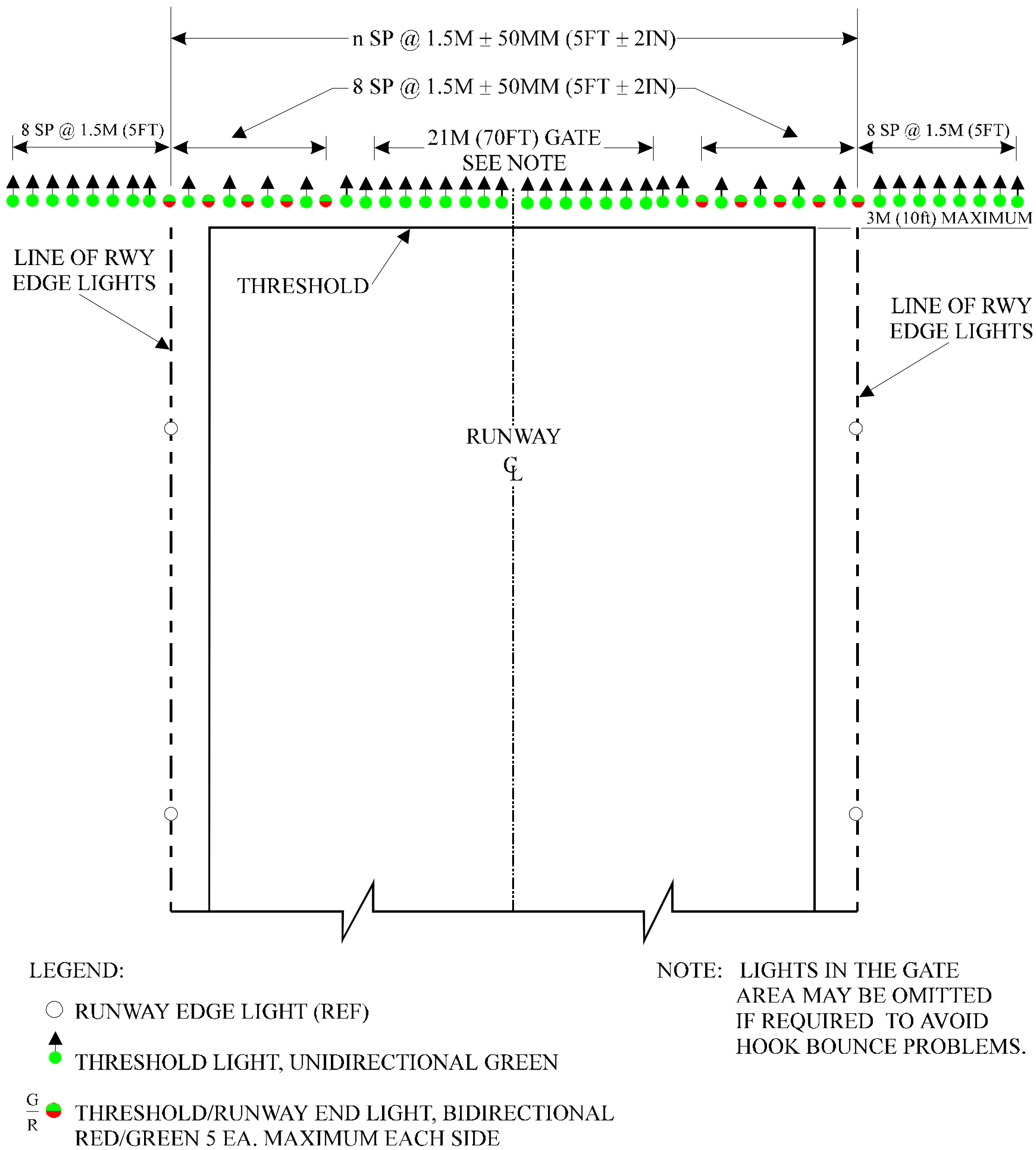
4.3.9. See FAA AC 150/5345-46 and AC 150 5340-24 for more information.

4.4. Threshold Lights:

4.4.1. Purpose. Threshold lights provide positive identification of the beginning of the operational runway surface for approaching aircraft at night or under instrument weather conditions.

4.4.2. Configuration. Install threshold lights in a line perpendicular to the extended runway centerline outside the usable landing area a distance of not more than 3 meters (10 feet). The line of lights is symmetrical about the runway centerline and extends 12 meters (40 feet) outboard of the lines of runway edge lights. (See figure 4.3). Determine the position of the lights as follows:

Figure 4.3. Threshold Light Configuration.



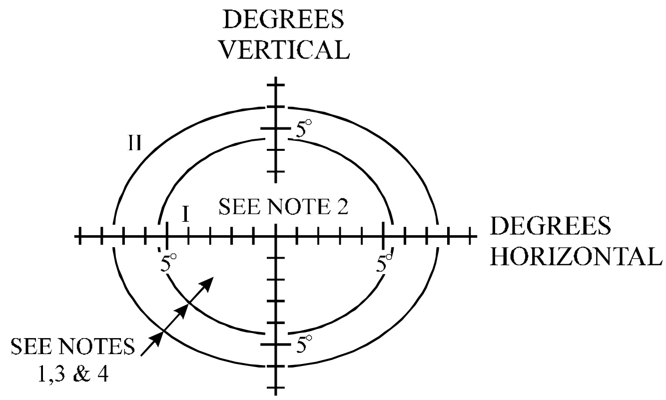
4.4.2.1. Place a light where the line of threshold lights intersects the line of runway edge lights. Then place lights at 1.5 meters (5 feet) for a distance of 12 meters (40 feet) outboard of the runway edge light lines.

4.4.2.2. Place lights at uniform intervals between the lines of runway edge lights and along the line of the threshold lights. The interval shall be as near to 1.5 meters (5 feet) as possible and shall not exceed 1.55 meters (5 feet 2 inches). The threshold bar may be gated to lessen the problem of tail hook bounce (if waivered by the MAJCOM). This is done by eliminating those lights in the center 21 meters (70 feet) portion of the threshold. Note that blank covers must be flush.

4.4.3. Photometric Requirements:

4.4.3.1. High Intensity Threshold Lights. Optimum aiming of lights depends on the design and output of the fixtures used in the system. Light fixtures may be designed to cover several applications and may have fixed patterns and aiming angles which differ from this manual. Light aiming and patterns other than those given in the standard may be used if the resultant light pattern produces equivalent light intensities in the areas required by the standard. The lights shall be uni-directional green aimed into the approach and shall have intensities, as shown in figure 4.4, when used with high intensity runway edge lights or approach lights. The light beams are aimed parallel with the runway centerline and angled upward at an angle of 4.5 degrees. High intensity threshold lights shall operate at five intensity levels, together with the associated runway edge lights or approach lights when installed. When used with medium intensity runway edge lights, their intensities shall be reduced to levels comparable with the runway lights.

Figure 4.4. Threshold Light Photometric Requirements.



THRESHOLD LIGHTS, GREEN

	I=50%	II=10%
a	5.5°	7.5°
b	4.5°	6.0°

NOTES:

1. ALL CONTOURS ARE ELLIPSES CALCULATED BY EQUATION $\frac{X^2}{a^2} + \frac{Y^2}{b^2} = 1$
2. THE MINIMUM AVERAGE CANDELA IN GREEN LIGHT OF THE MAIN BEAM IS 10,000 CD FOR HIGH INTENSITY SYSTEMS AND 100 CD FOR MEDIUM INTENSITY SYSTEMS.
3. MAXIMUM INTENSITY SHOULD NOT EXCEED 1.5 TIMES ACTUAL AVERAGE.
4. PORTIONS OF THE LIGHT BEAM CUT OFF BY THE MOUNTING SURFACE MAY BE DISREGARDED.

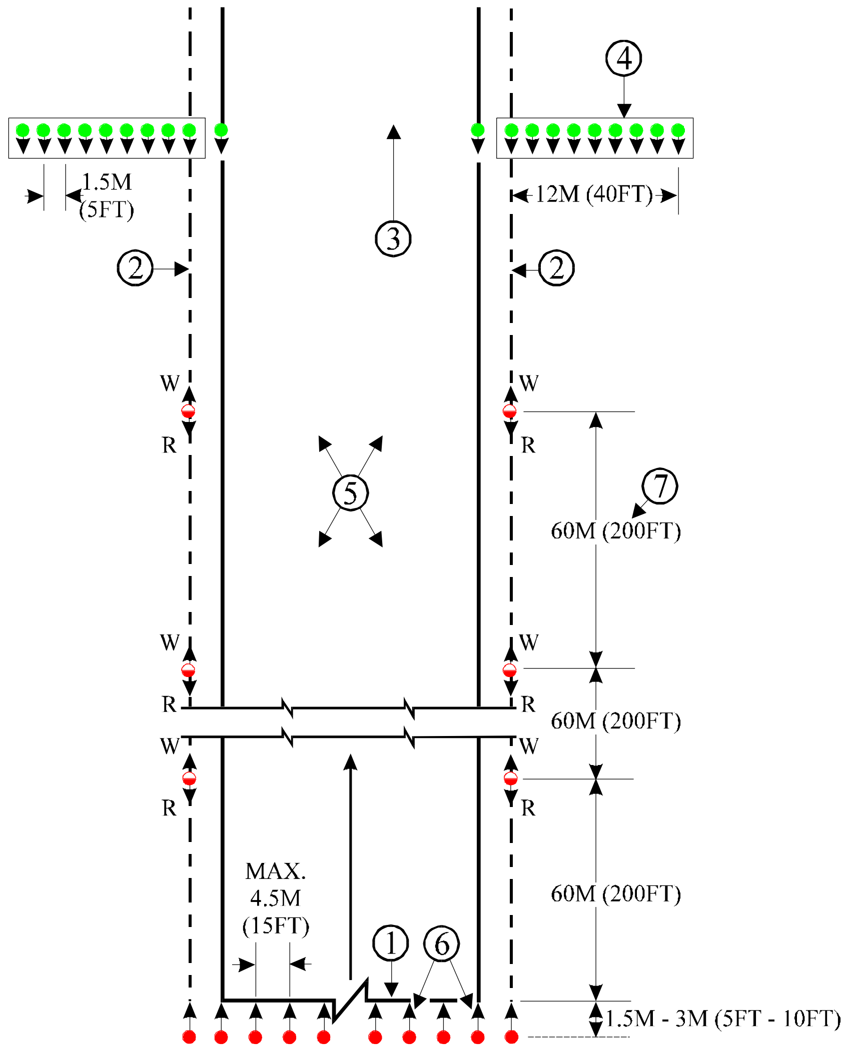
4.4.3.2. Medium Intensity Threshold Lights. The lights shall be uni-directional green and aimed toward the approach. The average intensity shall be 100 candelas minimum in the main beam with a beam pattern as shown in figure 4.4. They shall operate at three intensities, together with the associated runway edge lights.

4.4.4. Equipment. Inboard: Use in pavement fixtures with no part of the fixture protruding more than 0.025 meters (1 inch) above the surrounding surface. Outboard: Use elevated fixtures, frangible mounted. Where the opposite direction runway end is collocated with the threshold, runway end lights may be incorporated into threshold light fixtures. The number of bi-directional fixtures shall be the minimum required to satisfy the requirement for end light fixtures. Where traffic patterns or arresting gear equipment interfere with the use of elevated fixtures, in pavement fixtures shall be used. (See Chapter 12, paragraph 12.10.3).

4.4.5. Power Requirements. Where no approach lights are installed, the threshold lights shall all be powered and controlled with the associated runway edge lights. Connect to the HIRL series circuit. Emergency and automatic transfer requirements are the same as for HIRL.
4.4.6. Control Requirements. Provide remote on and off and intensity control through the runway edge light controls.
4.4.7. Monitoring Requirements. Threshold lights have the same monitoring requirements.
4.4.8. Compliance with International Military Standards:
4.4.8.1. NATO. The standard meets NATO STANAG 3316, Airfield Lighting, for high intensity threshold lights.
4.4.8.2. ASCC. The standard meets ASCC AIR STD 65/35, Aerodrome Lighting, for high intensity threshold lights.
4.4.9. See FAA AC 150/5345-46 for more information.

4.5. Lighting with Displaced Thresholds:
4.5.1. General. The threshold, which is located at the beginning of the landing area, may sometimes not be located at the beginning of the full strength runway pavement. It may be displaced because of obstructions or other operational problems. The area of full strength pavement in front of the threshold may be required for takeoff or for rollout on landings from the opposite direction. Where this is the case, changes to the standards for runway lighting are required.
4.5.2. Configuration for Displacement. See figure 4.5 for a typical layout of displaced thresholds.
4.5.2.1. Install threshold lights as specified in paragraph 4.4, with dimensions referenced to the theoretical beginning of the usable landing area.
4.5.2.2. Install runway end lights as specified in paragraph 4.6, with dimensions referenced from the end of the usable takeoff and rollout area.
4.5.2.3. Modify runway edge lights in the displaced area to show red light toward the approach direction and white light toward the runway opposite the approach.
4.5.2.4. The runway centerline lights facing the approach direction in the displaced area shall be blanked out if the length of the displacement is less than 210 meters (700 feet). If the displacement is 210 meters (700 feet)) or greater, circuit the centerline lights in the area separately. Provide the capability to turn runway centerline lights off during landing operations. If a high intensity approach light system is installed, this switching capability is not required.
4.5.2.5. Install approach lights and visual approach slope indicators, such as PAPI, as specified in this standard using the theoretical beginning of the usable landing area (threshold) as the reference. Ensure coordination has been performed for relocation of any instrument approach aids.
4.5.3. Photometric Requirements:
4.5.3.1. Provide runway edge lights in the displaced area with red filters in the approach direction with the opposite direction blanked out.
4.5.3.2. Disable any approach lighting system, or any touchdown zone (TDZ) lights serving that end of the runway.
4.5.3.3. Runway Distance Markers (RDM) number panels facing toward the opposite end approach shall be blanked or temporarily replaced with the new number panels showing the shorter distance. Renumbering shall be done so that at least 300 meters (1,000 feet) remain between the last number (#1) and the displaced runway end.

Figure 4.5. Displaced Threshold Light Configuration.



(1) INDICATES END OF RUNWAY PAVEMENT (TAKE-OFF THRESHOLD).

(2) RUNWAY EDGE LIGHT LINE.

(3) INDICATES LOCATION OF THRESHOLD OF USABLE LANDING AREA.

(4) WINGED OUT THRESHOLD BAR MARKING LOCATION OF THRESHOLD OF USABLE LANDING AREA.

(5) INDICATES OPERABLE PAVEMENT FOR GROUND AIRCRAFT MOVEMENT BETWEEN LANDING AND TAKE-OFF THRESHOLD.

(6) INBOARD RUNWAY END LIGHT LIGHTS MARKING LOCATION OF TAKE-OFF THRESHOLDS.

(7) UNIFORM SPACING BETWEEN RUNWAY EDGE LIGHTS IS TO APPROACH BUT NOT EXCEED 60M (200FT).

LEGEND:

THRESHOLD LIGHT, UNIDIRECTIONAL GREEN. PROVIDE BIDIRECTIONAL FOR FIXTURE IN LINE WITH RUNWAY EDGE LIGHT IF DISTANCE TO UPWIND EDGE LIGHT EXCEEDS 45M (150FT) -WHITE LIGHT.

RUNWAY END LIGHT, UNIDIRECTIONAL, RED.

RUNWAY EDGE LIGHT, ELEVATED, BIDIRECTIONAL WHITE/RED.

4.5.3.4. Runway centerline lights shall have red filters replaced or relocated to conform to the standard for the last 900 meters (3,000 feet) of the runway.
4.5.4. Equipment. See the applicable section of Chapter 12 for the threshold lights at paragraph 12.10.3.
4.5.5. Power, Control and Monitoring. (See paragraph 4.4).
4.5.6. Compliance with International Standards.
4.5.6.1. NATO. Same as paragraph 4.4.
4.5.6.2. ASCC. Same as paragraph 4.4.
4.5.7. See FAA AC 150/5345-46 for more information.

4.6. Runway End Lights:
4.6.1. Purpose. Runway end lights define the end of the operational runway surface for aircraft for landing, roll out or takeoff. They are required on all operational runways.
4.6.2. Configuration. Runway end lights consist of 10 red lights in two groups of 5 lights. The groups shall be located symmetrically about, and on a line perpendicular to, the runway centerline within 3 meters (10 feet) of the end of the usable runway surface. The lights in each group shall have a uniform spacing between 3 meters (10 feet) and 4.5 meters (15 feet). The out-board-most light in each group must be in line with the line of the runway edge lights on that side of the runway. (See figure 4.6). Runway end lights are usually, but not always, co-located with the opposite end threshold lights. Where they are co-located runway end lights may be incorporated into the opposite end threshold fixtures provided the photometric requirements are met. (See figure 4.3). When runway width exceeds 45 meters (150 feet) additional runway end lights may be added, but only uni-directional fixtures should be used for these additional lights.
4.6.3. Photometric Requirements. Optimum aiming of lights depends on the design and output of the fixtures used in the system. Light fixtures may be designed to cover several applications and may have fixed patterns and aiming angles which differ from this manual. Light aiming and patterns other than those in the standard may be used if the resultant light pattern produces equivalent light intensities in the areas required by the standard. Runway end lights shall be used, uni-directional red, facing toward the runway. When used with HIRL, they shall meet the intensity requirements shown in figure 4.7. The lights shall be aimed parallel with the runway centerline and upward at 3 degrees above the horizontal. They shall operate at five intensities as specified in paragraph 4.2.3 for HIRL. Runway end lights used with MIRL shall have reduced intensities compatible with the edge lights and operate at three intensity steps.
4.6.4. Equipment. Use in pavement fixtures with no part protruding more than 0.025 meters (1 inch) above the surrounding surface. Where the runway end is co-located with the opposite direction threshold, the threshold and runway end lights may not be incorporated into the same fixture unless the photometrics meet the requirements for both the red and green colors. (See Chapter 12, paragraph 12.10.4).
4.6.5. Compliance with International Military Standards.
4.6.5.1. NATO. These standards meet NATO STANAG 3316, Airfield Lighting.
4.6.5.2. ASCC. These standards meet ASCC AIR STD 65/35, Aerodrome Lighting, for runway end lights.
4.6.6. See FAA AC 150/5345-46 for more information.

4.7. Runway Centerline Lights (RCL):
4.7.1. Purpose. The runway centerline lights provide lateral guidance during landing, rollout and takeoff roll under low visibility conditions. They are required for Categories II and III instrument operations.
4.7.2. Configuration. The runway centerline lighting system is a straight line of lights which runs parallel with and within 0.6 meters (2 feet) of the runway centerline. (See figure 4.8). The lights are spaced 15

meters (50 feet) apart. The lighting system extends from 22.5 meters (75 feet) of the upwind end of the runway.

Figure 4.6. Runway End Light Configuration.

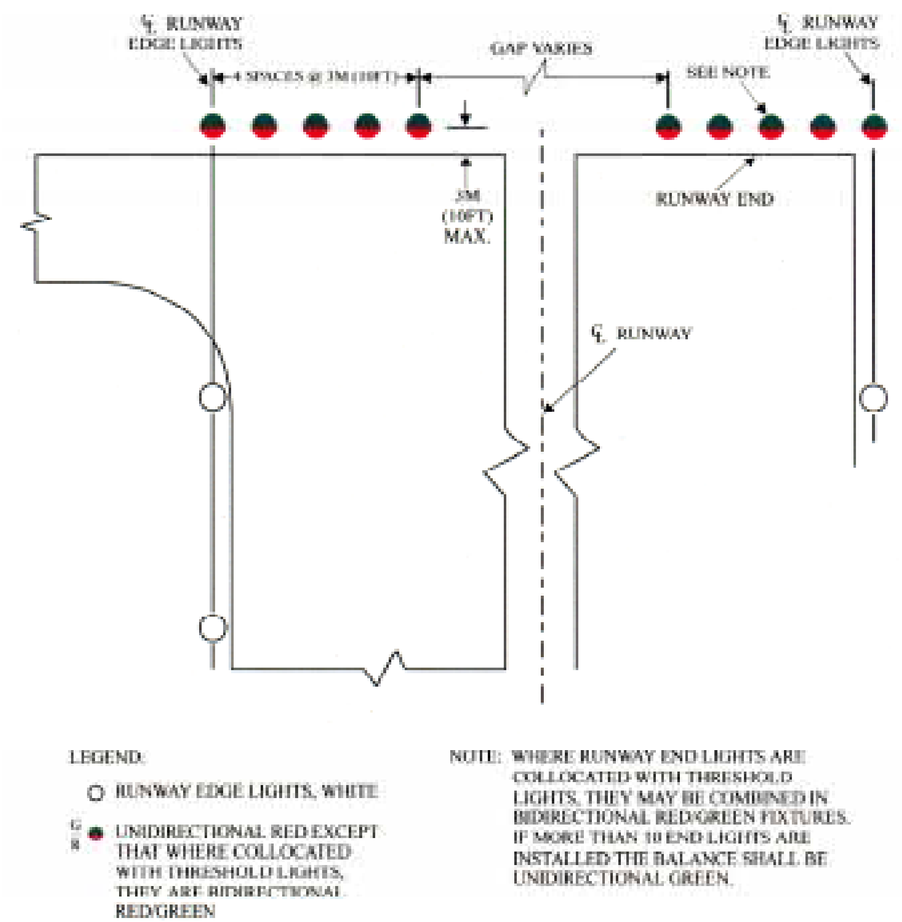
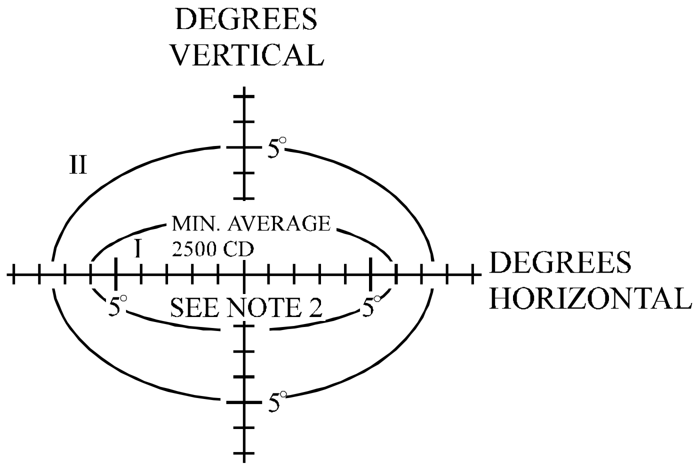


Figure 4.7. Runway End Light Photometrics.



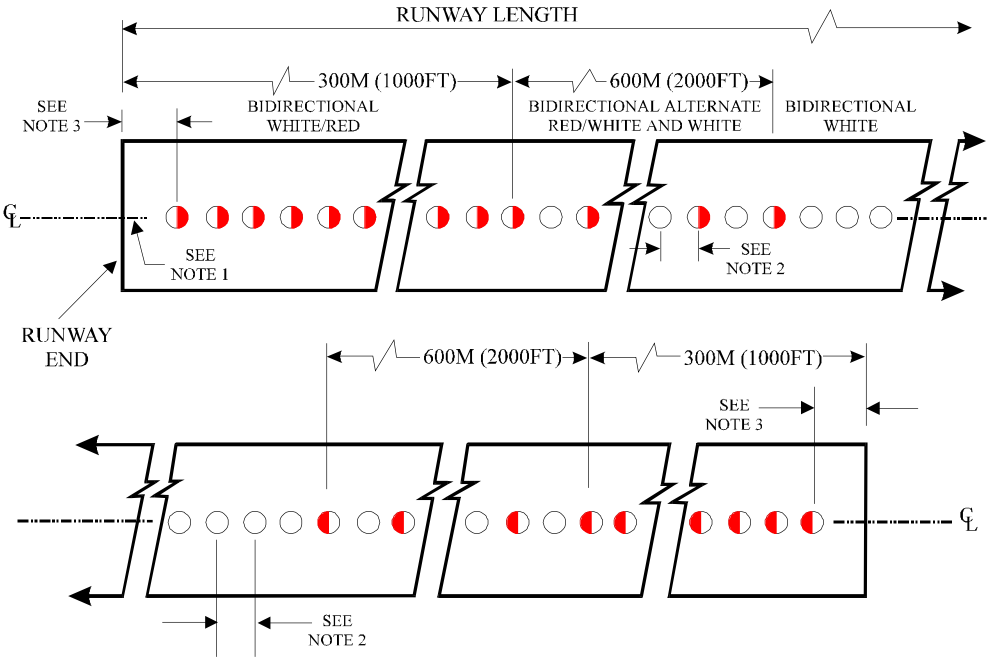
RUNWAY END LIGHT, RED

	I=50%	II=10%
a	6.0°	7.5°
b	2.25°	5.0°

NOTES:

1. ALL CONTOURS ARE ELLIPSES CALCULATED BY EQUATION $\frac{X^2}{a^2} + \frac{Y^2}{b^2} = 1$
2. THE MINIMUM AVERAGE INTENSITY OF THE MAIN BEAM (INSIDE CONTOUR I) IS 2,500 CD, AVIATION RED. MAXIMUM INTENSITY SHOULD NOT EXCEED 1.5 TIMES ACTUAL AVERAGE INTENSITY.
3. MINIMUM INTENSITY OF I=50% AND II=10% OF REQUIRED MAIN BEAM INTENSITY.

Figure 4.8. Runway Centerline Light Configuration.



NOTES:

1. THE RCL LINE MAY BE OFFSET NOT MORE THAN 0.6M (2FT) RIGHT OR LEFT OF THE RUNWAY CENTERLINE. THE LATERAL TOLERANCE FROM THE LINE OF LIGHTS + 25MM (1 IN).
2. THE RCL SHALL BE EQUALLY SPACED AT 7.5M (25FT) FOR TYPE L-852N LIGHTS, AND AT 15M (50FT) FOR FAA TYPE L-850A LIGHTS. THE LONGITUDINAL TOLERANCE IS + 0.6M (2FT).
3. THE FIRST LIGHT FROM EITHER END OF THE RUNWAY SHALL BE FOR TYPE L-852N LIGHTS NOT LESS THAN 3.85M (12.5FT) AND NOT MORE THAN 7.5M (25FT), AND FOR FAA TYPE L-850A LIGHTS NOT LESS THAN 15M (50FT) AND NOT MORE THAN 26.7M (87.5FT).

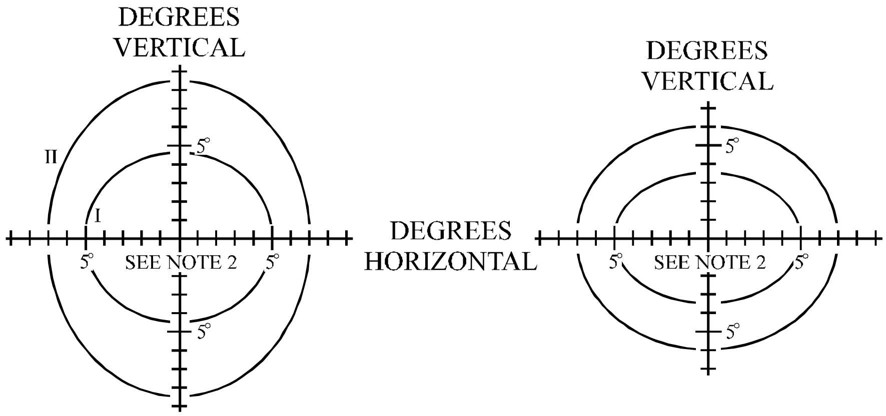
LEGEND:

○ BIDIRECTIONAL RCL - WHITE BOTH DIRECTIONS

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

4.7.3. Photometric Requirements. Optimum aiming of lights depends on the design and output of the fixtures used in the system. Light fixtures may be designed to cover several applications and may have fixed patterns and aiming angles which differ from the standard. Light aiming and patterns other than those given in the standard may be used if the resultant light pattern produces equivalent light intensities in the areas required by the standard. The centerline lights shall be bi-directional and emit white light. They shall be color coded on the final 900 meters (3,000 feet) portion. (See figure 4.9). The lights shall meet the intensity requirements shown in figure 4.7. They shall be aimed parallel with the runway centerline and upward at 4.5 degrees. They shall operate at 5 intensity steps as specified in paragraph 4.2 for runway edge lights.

Figure 4.9. Runway Centerline Light Photometric Configuration.



A. CENTERLINE LIGHTS, HOOK-RESISTANT, 7.5M (25FT) SPACING

B. CENTERLINE LIGHTS, HIGH-INTENSITY, 15M (50FT) SPACING

A:

	I=50%	II=10%
a	5.0°	7.0°
b	4.5°	8.5°

B:

	I=50%	II=10%
a	5.0°	7.0°
b	3.5°	6.0°

NOTES:

1. ALL CONTOURS ARE ELLIPSES CALCULATED BY EQUATION $\frac{X^2}{a^2} + \frac{Y^2}{b^2} = 1$
2. THE MINIMUM AVERAGE INTENSITY OF THE MAIN BEAM (INSIDE CONTOUR I) IS FOR 7.5M (25FT) SPACING, 250 CD (WHITE) AND 250 CD (RED); AND FOR 15M (50FT) SPACING 5000 CD AND 1000 CD (RED). MAXIMUM INTENSITY SHOULD NOT EXCEED 1.5 TIMES ACTUAL AVERAGE INTENSITY.
3. MINIMUM INTENSITY OF I=50% AND II=10% OF REQUIRED MAIN BEAM INTENSITY.

4.7.4. Adjustment and Tolerances. The line of lights may be offset a maximum of 0.6 meters (2 feet) from the runway centerline to avoid interference with construction joints. Installation tolerance for fixtures is +/- .025 meters (1 inch) from the design location. The mounting surface of the fixture shall be level within 1 degree in any direction and the horizontal shall be within 1 degree of that specified.

4.7.5. Equipment. Use in pavement fixtures with no part protruding more than 0.01 meters (0.5 inch) above the surrounding surface. Up to three fixtures may be omitted in the vicinity of arresting gear pendant cables to avoid hook bounce and minimize light damage. (See Chapter 12, paragraph 12.10.5).

4.7.6. Power Requirements. For Categories II and III operations, provide a main and standby power system with automatic transfer within one second of a failure of the system in use. For Category I operation, 15 second transfer is adequate.

4.7.7. Control Requirements. Provide remote on/off and intensity control.

4.7.8. Monitoring Requirements. When supporting of operations below 720 meters (2,400 feet) RVR, provide system monitoring which, at minimum, gives positive indication at the control facility that power is being delivered to the lights.

4.7.9. Compliance with International Military Standards:

4.7.9.1. ASCC. These standards meet the requirements of AIR STD 65/35, Aerodrome Lighting for CAT II conditions.

4.7.9.2. NATO. These standards meet the NATO STANAG 3316, Airfield Lighting.

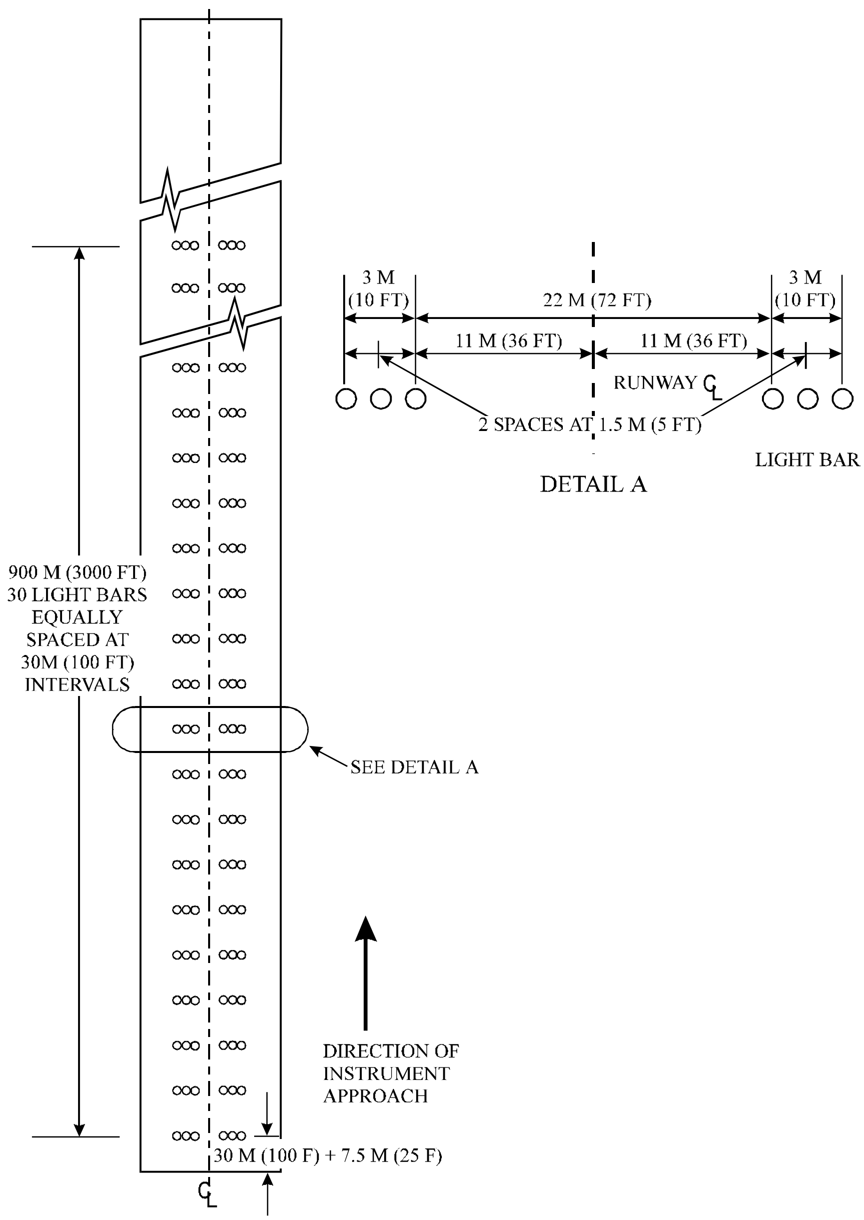
4.7.9.3 See FAA AC 150/5340-4 for more information.

4.8. Touchdown Zone Lights (TDZL):

4.8.1. Purpose. Touchdown zone lights provide continuity when crossing the threshold into the touchdown area and provide visual cues during the flare out and touchdown phases of the landing. They are required where CAT II or III operations are to be performed.

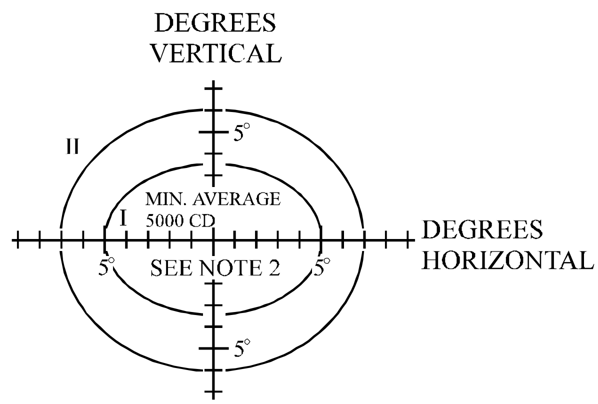
4.8.2. Configuration. The touchdown zone lighting system presents, in plain view, two rows of high intensity light bars arranged symmetrically about the centerline of the runway. The two rows of light bars are located within the paved area of the runway in order to define that portion of the landing area used for flare and touchdown. The system extends from the threshold of the usable landing area toward the upwind end of the runway, a distance of 900 meters (3,000 feet). The light bars are in rows at 30 meters (100 feet) intervals. Each light bar contains three lights spaced at 1.5 meters (5 feet) on center with the inboard light located 11 meters (36 feet) from the runway centerline. (See figure 4.10).

Figure 4.10. Touchdown Zone Light Configuration.



4.8.3. Photometric Requirements. Optimum aiming of the lights depends on the design and layout of the fixtures used in the system. The light fixtures may be designed to cover several applications and may have fixed patterns and aiming angles which differ from this manual. The light aiming and patterns other than those cited in this standard may be used if the resultant light pattern produces equivalent light intensities in the areas regulated by the standard. TDZ lights shall emit uni-directional aviation white light with intensities as shown in figure 4.11. They shall be toed in 4 degrees toward the centerline and aimed upward 5.5 degrees. The lights shall operate at five intensity steps as specified in paragraph 4.2 for HIRL.

Figure 4.11. Touchdown Zone Light Photometric Requirements.



TOUCHDOWN ZONE LIGHTS, WHITE

	I=50%	II=10%
a	5.0°	7.0°
b	3.5°	6.0°

NOTES:

1. ALL CONTOURS ARE ELLIPSES CALCULATED BY EQUATION $\frac{X^2}{a^2} + \frac{Y^2}{b^2} = 1$
2. THE MINIMUM AVERAGE INTENSITY OF THE MAIN BEAM (INSIDE CONTOUR I) IS 5,000 CD AVIATION WHITE. MAXIMUM INTENSITY SHOULD NOT EXCEED 1.5 TIMES ACTUAL AVERAGE INTENSITY.
3. CONTOURS I=50% AND II=10% INDICATE THE MINIMUM VALUES AT THESE PERCENTAGES OF THE MAIN BEAM INTENSITY.
4. THE INTENSITY REQUIREMENTS FOR THE ANGLES BELOW THE SURFACE OF THE PAVEMENT MAY BE DISREGARDED.

4.8.4. Adjustment and Tolerances. The location of the pairs of light bars may be adjusted a maximum of 0.6 meters (2 feet) longitudinally to avoid construction joints. Installation tolerance for the fixtures is 0.27 meters (11 inches) from the design location in any direction. The mounting surface of the fixture shall be level within 1 degree in any direction and the horizontal aiming shall be within 1 degree.
4.8.5. Equipment. Use in pavement fixtures with no part protruding more than 0.01 meters (0.5 inch) above the surrounding surface. (See Chapter 12, paragraph 12.10.6).
4.8.6. Power, Control and Monitoring. The requirements in paragraphs 4.7.6 through 4.7.8 for RCLs apply.
4.8.7. Compliance with International Standards:

4.8.7.1. ASCC. These standards meet the requirements of AIR STD 65/35, Aerodrome Lighting for CAT II conditions.
4.8.7.2. NATO. These standards meet the requirement of STANAG 3316, Airfield Lighting.
4.8.8. See FAA AC 150/5340-4 for more information.

4.9. Runway Distance Markers (RDM):
4.9.1. Purpose. RDMs are installed to indicate to pilots how much runway distance remains in thousands of feet to complete a takeoff or landing roll. A runway distance marking system is required for a runway on which jet aircraft operations are conducted. They are recommended for runways where only propeller-type aircraft operations are conducted.
4.9.2. Configuration. A RDM system consists of two rows of markers (signs) located along the sides of the runway, with one row on each side of the runway. The rows of markers are parallel to the runway centerline and equidistant from the runway edge at not less than 15 meters (50 feet) and not more than 22.5 meters (75 feet). The markers are spaced longitudinally at 300 meters (1,000 feet) intervals to the upwind end of the runway. The distance information is shown by a numeral indicating the distance remaining in thousands of feet on the vertical face of each marker. Numerals are shown on both faces of the markers so the distance remaining can be seen in either direction of operation. Locations shall be determined as shown in figures 4.12 and 4.13.

Figure 4.12. Runway Distance Marker Configuration.

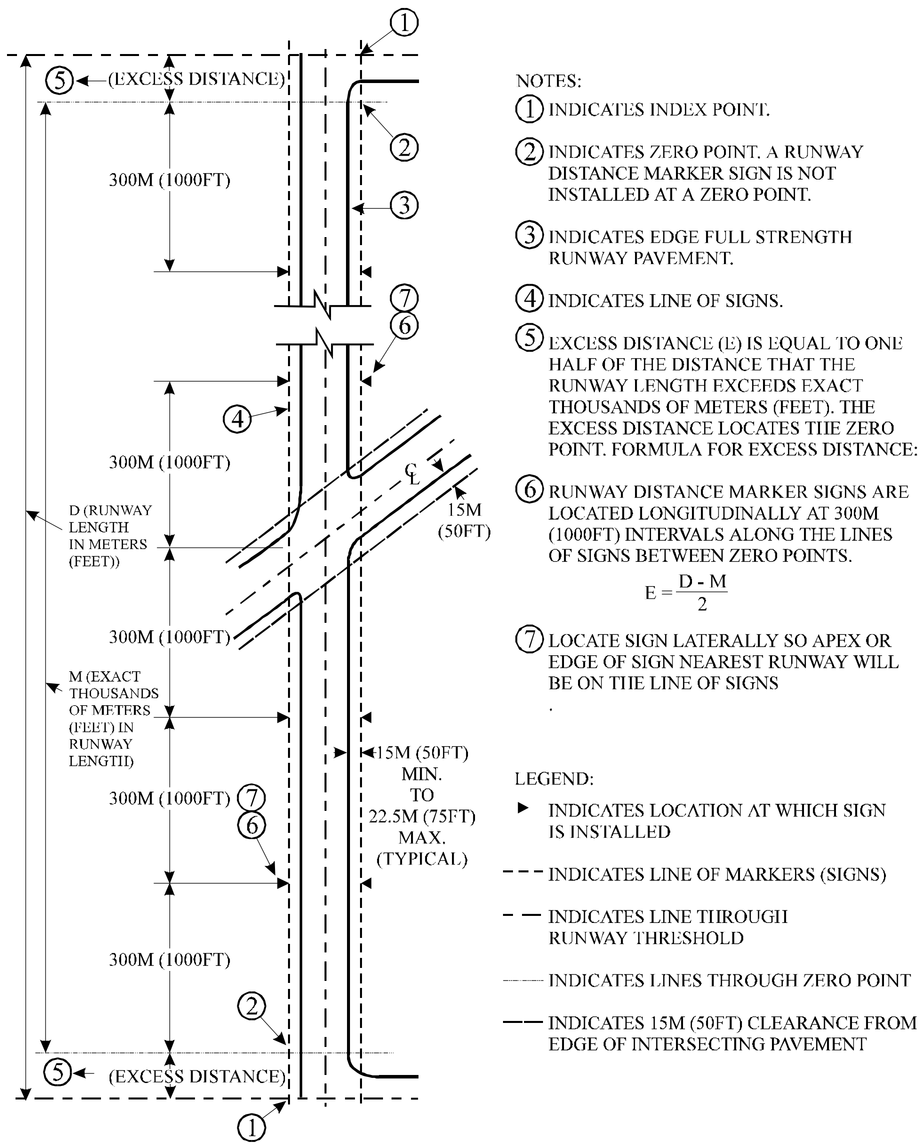
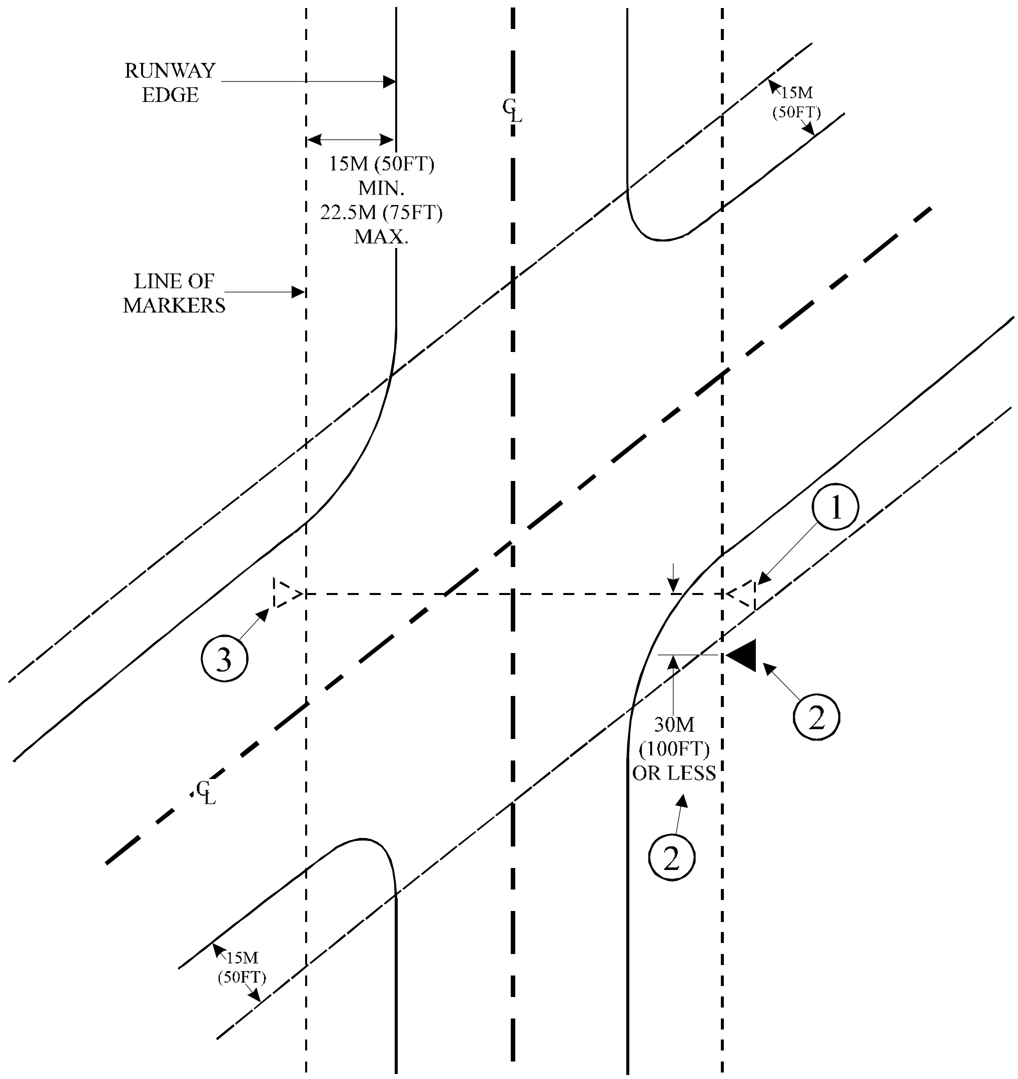


Figure 4.13. Runway Distance Marker Configuration (Intersections).



NOTES:

① INDICATES SIGN LOCATION CLOSER THAN 15M (50FT) TO EDGE OF INTERSECTING PAVEMENT.

② INDICATES ADJUSTED SIGN LOCATION. THE ADJUSTED LOCATION IS 30M (100FT) OR LESS FROM LOCATION DESIGNATED BY NOTE 1, BUT IS NO MORE THAN 15M (50FT) FROM EDGE OF INTERSECTING PAVEMENT.

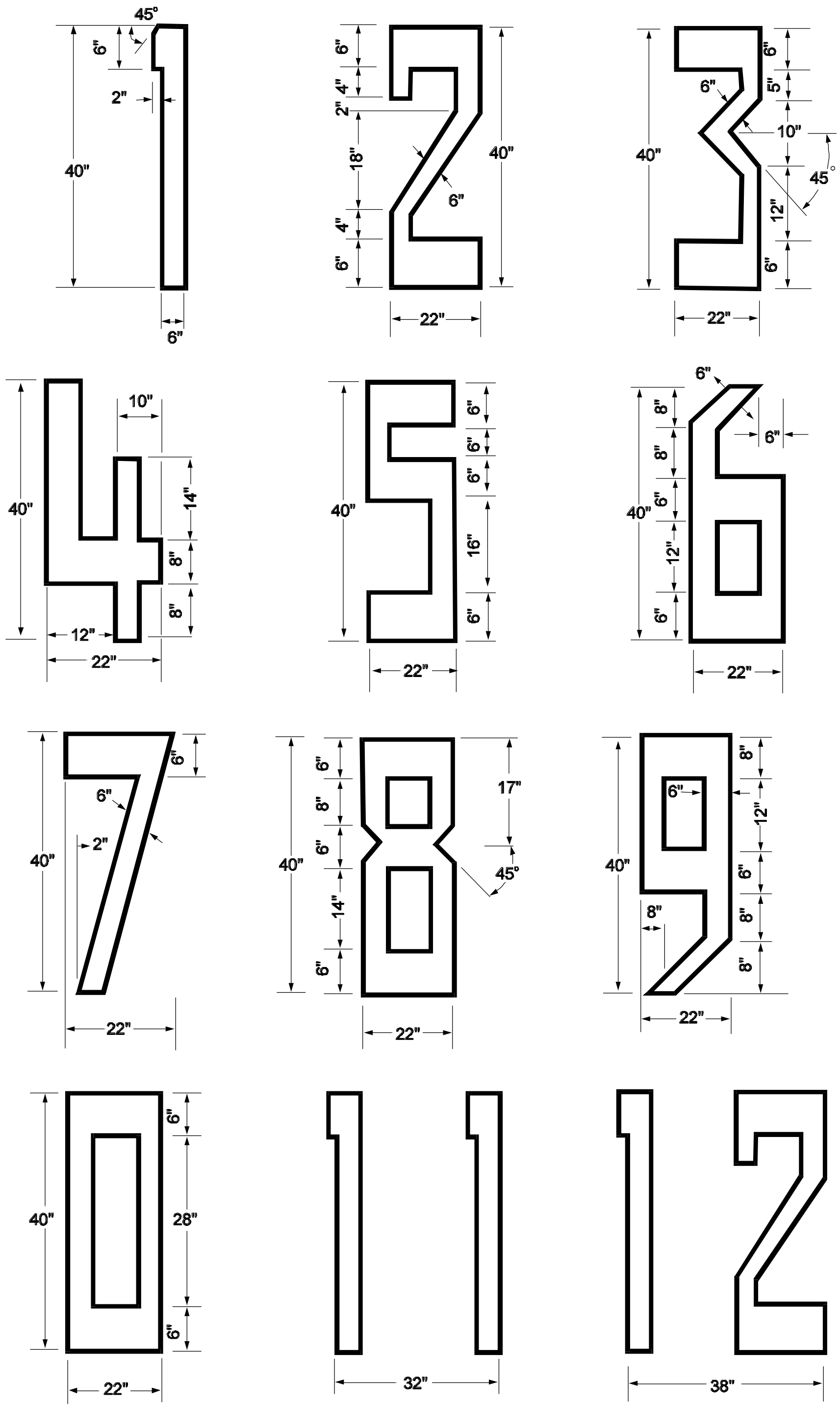
③ OMIT THIS MARKER. IT CAN NOT ADEQUATELY CLEAR THE INTERSECTING PAVEMENT.

4.9.3. Characteristics. Markers shall be readable from a minimum distance of 150 meters (500 feet) under meteorological visibility conditions of 900 meters (3,000 feet) by day or night.

4.9.3.1. The signs shall be internally illuminated displaying translucent white numerals on a black background.

4.9.3.2. The numerals shall be 1 meter (3.25 feet) high. The stroke shall be 0.15 meters (6 inches) wide and the breath of the figure shall be 0.55 meters (22 inches) wide. They may be styled as shown in figures 4.14 or figure 4.15. The style selected shall be used on all markers on a runway. A typical RDM is shown in figure 4.16. See Chapter 12, paragraph 12.10.7.

Figure 4.14. Runway Distance Marker Numerals.



DIMENSIONS BY INCHES, MULTIPLY BY 25.4 TO OBTAIN mm.

Figure 4.15. Runway Distance Marker Numerals (Alternate).

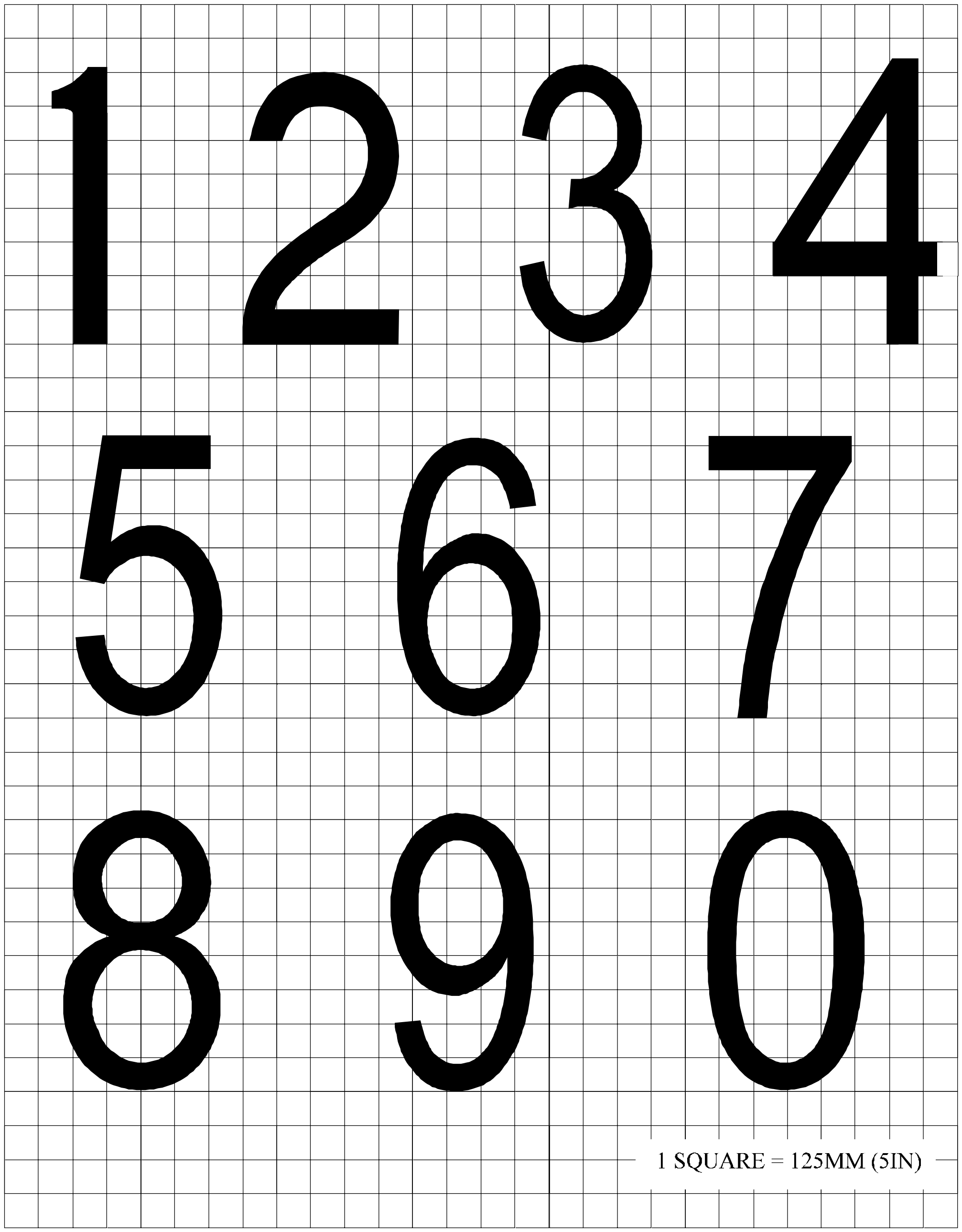
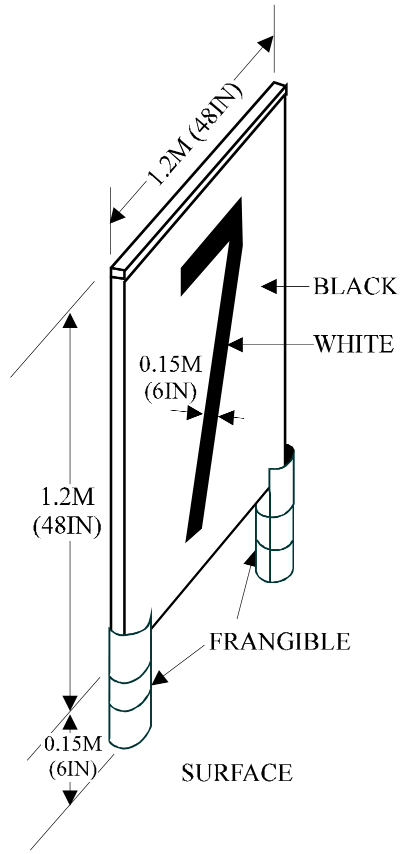


Figure 4.16. Runway Distance Marker Numerals (Unlighted).

TYPE: LOCAL MANUFACTURE, WHITE PAINT OR RETROREFLECTIVE TYPE NUMBER ON BLACK BACKGROUND.

OR

MARKER: FAA AC 150/5345-44, TYPE L-858B, SIZE 4, STYLE 4, UNLIGHTED.



4.9.3.3. If a training program for night VFR operations is to be conducted on an auxiliary airfield runway, retro-reflective tape may be used on markers (rather than internally illuminated numerals) provided the aircraft landing lights are adequate to illuminate the markers. Use of retro-reflective tape shall be approved by the MAJCOM operations and flight safety officer. A typical marker is shown in figure 4.17, one example of the colors is white numerals on a green reflective background.

Figure 4.17. Runway Distance Marker (Illuminated).

MARKER: FAA AC 150/5345-44, TYPE L-858B, SIZE 4, STYLE 3.

LAMP: TYPE AS DETERMINED BY MANUFACTURER.

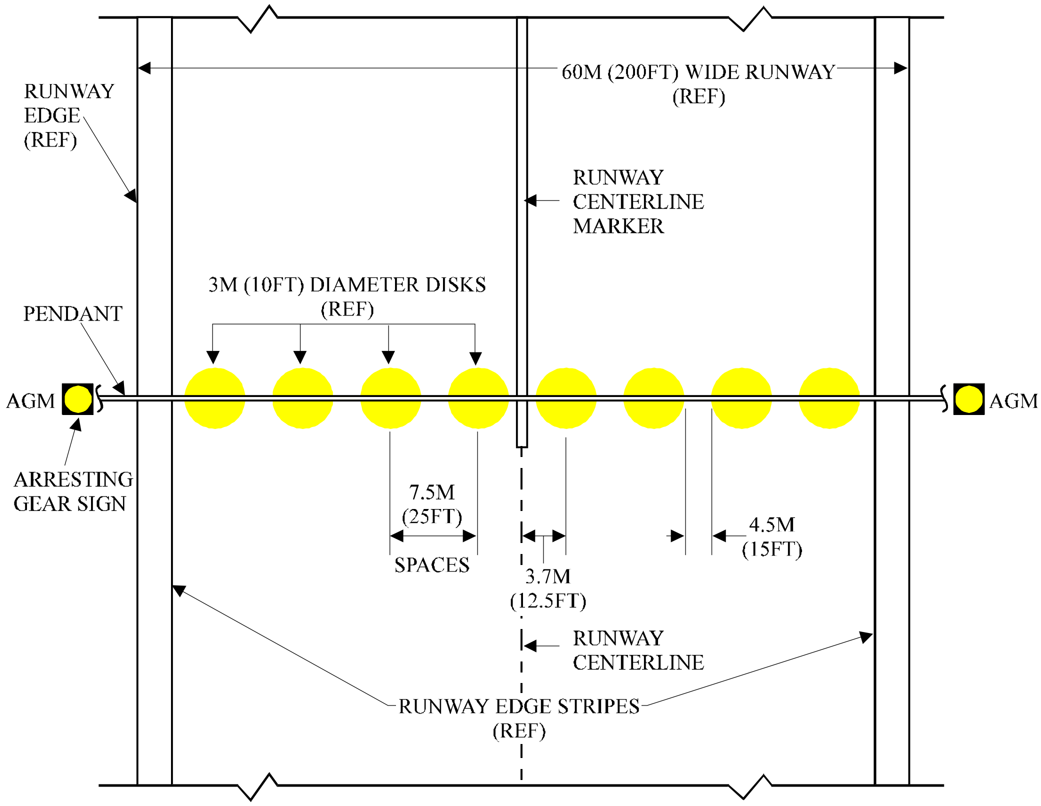
ISOLATION TRANSFORMER: RATING AS DETERMINED BY THE MANUFACTURER.

COLOR: WHITE NUMERALS ON A BLACK BACKGROUND OR FOR EXISTING INSTALLATIONS YELLOW NUMERALS ON A BLACK BACKGROUND.

4.9.4. Construction. The face of the marker shall be 1.2 meters (4 feet) square. Provide suitable frangible supports with the bottom edge of the marker not more than .15 meters (6 inches) above grade.
4.9.5. Power Requirements. Provide power from an independent circuit or from the runway edge light circuit. Markers should operate at the same intensity as the runway edge light from maximum down to not less than 50 percent maximum brightness even when the runway edge are set at a lower intensity setting.
4.9.6. Monitoring. There is no requirement for monitoring.
4.9.7. Compliance with International Standards:
4.9.7.1. ASCC. This standard meets the requirements of AIR STD 65/35, Aerodrome Lighting.
4.9.7.2. NATO. This standard meets the requirements of STANAG 3316, Airfield Lighting.
4.9.8. See FAA AC 150/5340-18 and AC 150/5345-44 for more information.

4.10. Arresting Gear Markers (AGM):
4.10.1. Purpose. AGMs identify the location of arresting gear pendant cables or barriers on the operational runway surface.
4.10.2. Configuration. Identify pendant cables or barriers with markers installed on both sides of the runway. Locate the markers in line with the cable, and equidistant from the runway edges not less than 15 meters (50 feet) nor more than 22.5 meters (75 feet) from the runway edge. Where RDMs are installed, locate the AGMs in the same line with them except where the pendant cable is within 6 meters (20 feet) of an RDM. In this case relocate the RDM to be in line with the AGM and outboard of it 1.5 meters (5 feet)

Figure 4.18. Arresting Gear Marker Configuration.



4.10.3. Characteristics. The requirement in paragraph 4.9.3 apply, except the white numeral is replaced with a yellow translucent circle approximately 1 meter (3.5 feet) in diameter facing both runway directions.

4.10.4. Construction. The requirements of paragraph 4.9.4 for RDMs apply. (See Chapter 12 paragraph 12.10.8).

4.10.5. Power, Control and Monitoring. Provide power for AGMs from the same source as the RDMs. The requirement of paragraphs 4.9.5 through 4.9.7 apply.

4.10.6. Compliance with International Standards:

4.10.6.1 ASCC. These standards meet the requirements of AIR STD 65/35, Aerodrome Lighting.

4.10.6.2 NATO. These standards meet the requirements of STANAG 3316, Airfield Lighting.

Chapter 5

STANDARDS FOR TAXIWAY LIGHTING

5.1. Taxiway Edge Lighting:

5.1.1. Purpose. Taxiway edge lights define the lateral limits and direction of a taxiing route. Taxiway edge lighting must be installed to be available for use as needed for the night VFR operations and for day and night instrument operations, except where taxiway centerline lights are installed.

5.1.2. Configuration. The configuration consists of a line of lights paralleling each side of the taxiway. Provide taxiway lighting for all regularly-used taxiing routes. Locate the line of taxiway edge lights on each side of the taxiway no more than 3 meters (10 feet) from the edge of the full-strength paving, and no closer than the edge of the full-strength paving. The line of lights on both sides of a taxiway shall be the same distance from their respective taxiway sides. When a runway or a portion of a runway is part of a regularly used taxiing route, provide taxiway lights in addition to the runway lights. To determine the spacing of lights along the taxiway length, such as intersections with runways and other taxiways, or changes in alignment or width, a discontinuity on one side of a taxiway applies to the other side as well; figure 5.1 illustrates most situations. Place an edge light at each discontinuity. For intersecting pavements, place them at the point of tangency (PT) of each fillet. Place a companion light on the side opposite the discontinuity as well.

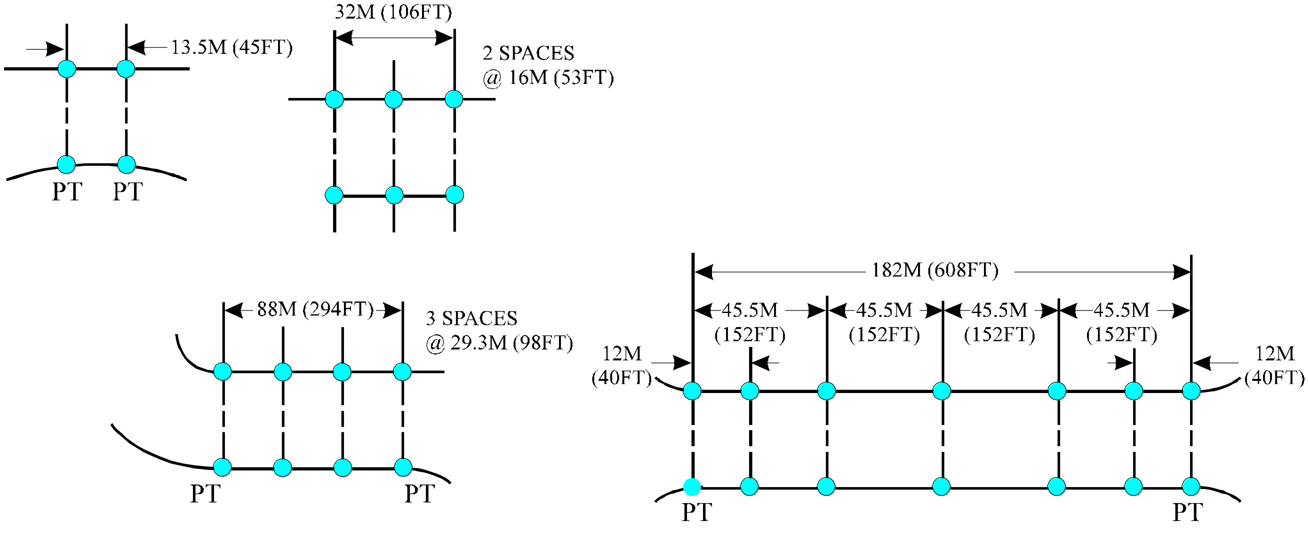
5.1.2.1. Straight Sections. Place edge lights along all straight taxiway edges at uniform intervals between the lights as in above. Where the length of the section is greater than 120 meters (400 feet), the spacing shall not exceed 60 meters (200 feet). If the section under consideration is opposite an intersecting taxiway or apron area, the uniform spacing shall not exceed 1/2 the width of the intersecting taxiway. Where the length of the section is less than 120 meters (400 feet) the spacing shall not exceed 30 meters (100 feet). Where the light spacing exceeds 30 meters (100 feet), place one additional light at the midpoint of the space at each end of the section. Where the section is opposite an ending taxiway, the uniform spacing shall not exceed 1/2 the width of the ending taxiway. Place companion lights along the opposite edge where there is no intersecting pavement. All companion lights shall be on lines perpendicular to the taxiway centerline. (See figure 5.1).

5.1.2.2. Curved Sections. Place edge lights along all curved taxiway sections. Uniformly space the lights on the outer line at a distance, not to exceed the value obtained from the formula given in figure 5.2. Place the lights on the inner line on radials from the outer line of lights, except where the resultant spacing would be less than 6 meters (20 feet). In this case, select a spacing not less than 6 meters (20 feet) for the inner line of lights and place the outer line of lights on radials from the inner line.

- Place uniformly spaced edge lights at all fillets as shown in figure 5.3. The spacing shall not exceed one half the width of the straight taxiway section. On all curves exceeding 30 degrees of arc, there shall be a minimum of three lights between the points of tangency (PTs).
- Where a taxiway ends at a crossing taxiway, place two yellow lights spaced 0.5 meters (1.5 feet) in the line of the edge lights of the crossing taxiway. Center them on the point where the extended centerline of the ending taxiway intersects. If a yellow light falls within 1.5 meters (5 feet) of a blue edge light, the blue light may be eliminated. (See figure 5.1).

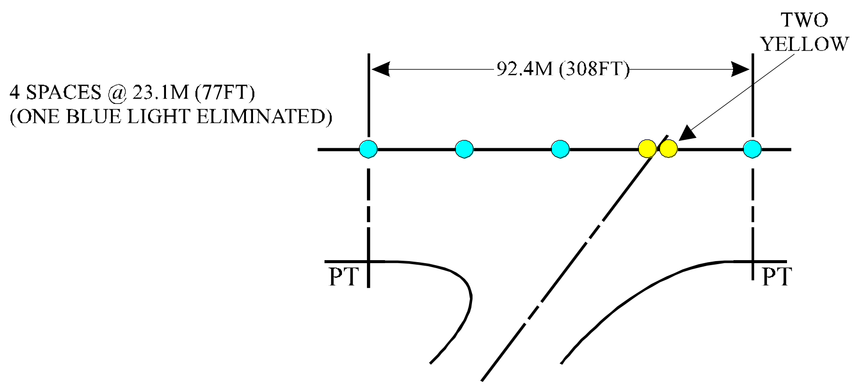
5.1.2.3. Entrance and Exit Lights. On intersections of taxiways with runways or aprons, place entrance/exit lights at the point of tangency of the taxiway fillet with the runway or apron. Do not place them at an intersection of taxiways. An entrance/exit light consists of 2 taxiway edge lights spaced 1.5 meters (5 feet) apart. One is located 1.5 meters (5 feet) out, on a line extending through the first light and perpendicular to the side of the runway or apron. (See figure 5.3).

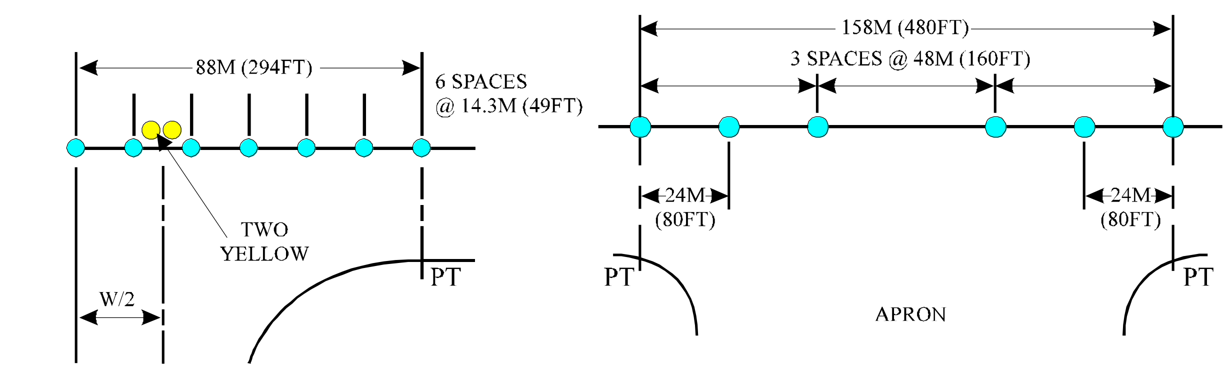
Figure 5.1. Taxiway Edge Lighting Configuration (Straight).



MAXIMUM SPACING = 30M (100FT)
TYPICAL EXAMPLES STRAIGHT SECTIONS
120M (400FT) OR LESS

MAXIMUM SPACING = 60M (200FT)
TYPICAL EXAMPLES STRAIGHT SECTIONS
MORE THAN 120M (400FT)

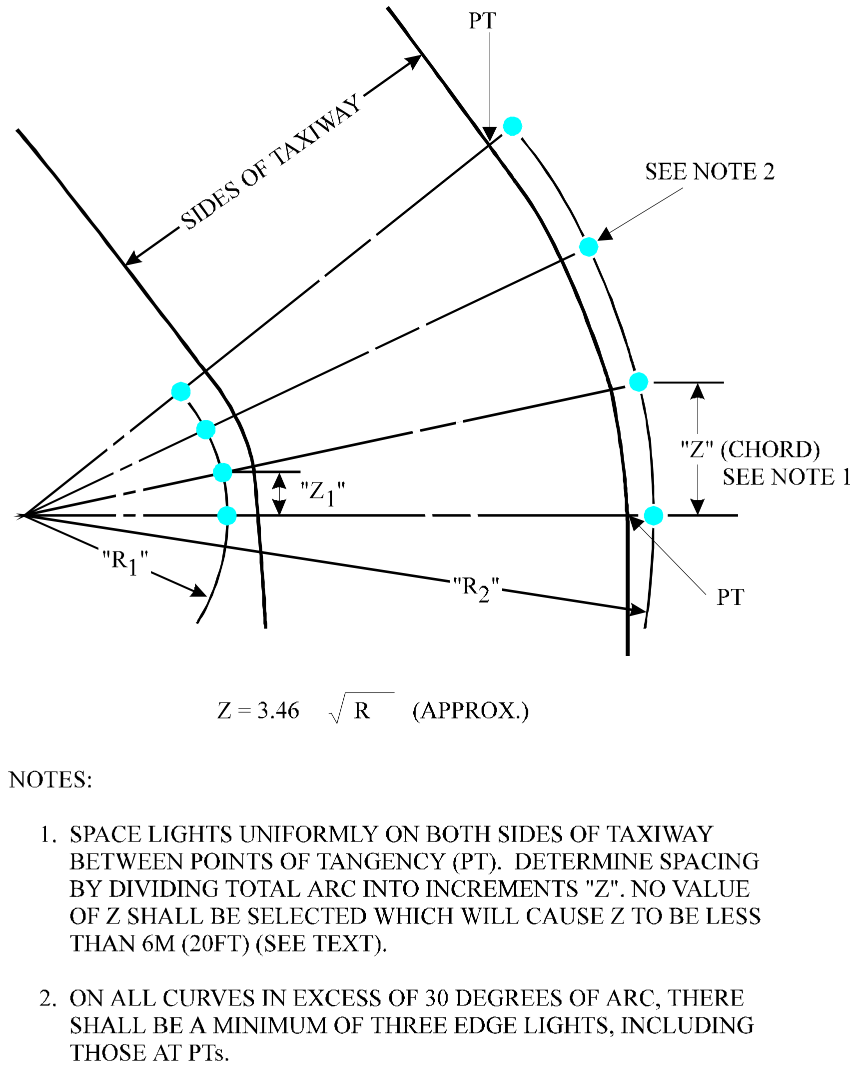




MAXIMUM SPACING = W/2
TYPICAL EXAMPLES SINGLE STRAIGHT EDGE (TXWY)
120M (400FT) OR LESS

MAXIMUM SPACING
TYPICAL EXAMPLES SINGLE STRAIGHT EDGES
MORE THAN 120M (400FT)

Figure 5.2. Taxiway Edge Lighting Configuration (Curves).



5.1.2.4. Apron Taxiways. For a taxiway that is adjacent to, or on the edge of, an apron, the taxiway edge lights are usually placed only on the side of the taxiway furthest from the apron. ("Taxiing" routes through an apron will not have these lights).

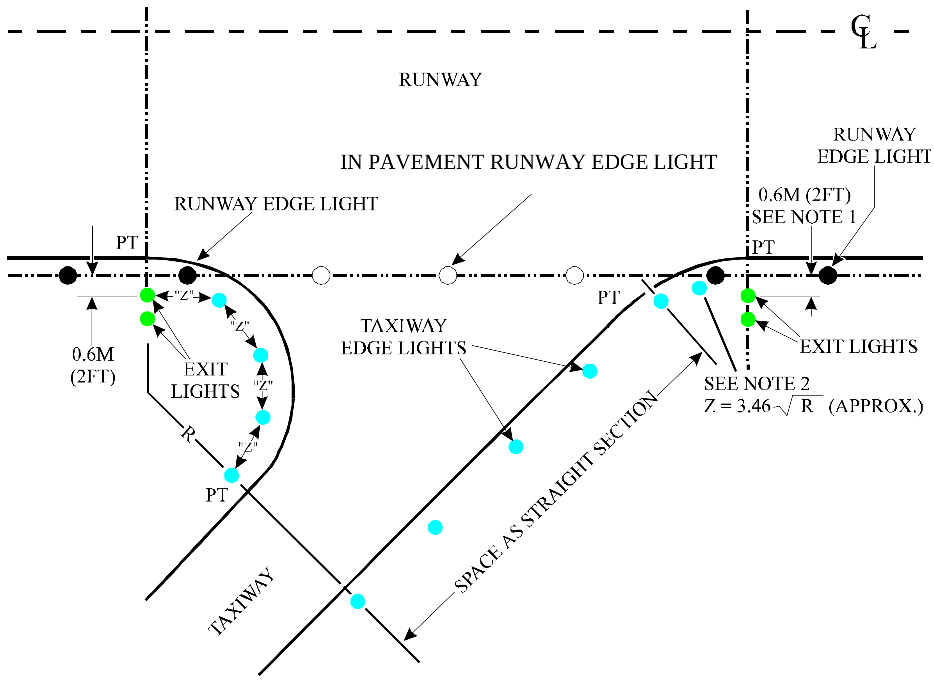
5.1.3. Tolerances. Adjust the longitudinal location of any light maximum of 1.5 meters (5 feet) to avoid installation problems. Move the companion light the same amount, if practical, to maintain the relationship between them. Install taxiway edge lights within 0.15 meters (6 inches) laterally or longitudinally of the design location.

5.1.4. Photometric Requirements. Optimum aiming of lights depends on the design and output of the fixtures used in the system. Taxiway edge lights shall be omni-directional and emit aviation blue light with a minimum intensity of 2 candelas from 0 to 6 degrees vertically and a minimum of 0.2 candelas at all other vertical angles.

5.1.5. Equipment. Use frangible mounted elevated fixtures in all areas except as noted below. Mount elevated fixtures a maximum of 0.35 meters (14 inches) above grade. Where there are frequent snow accumulations of 0.30 meters (12 inches) or more, the mounting height may be increased to 0.60 meters (24 inches).

5.1.5.1. Size the fixture base which supports the elevated fixture and houses the isolation transformer to accept a in pavement fixture. This facilitates future runway and taxiway configuration changes or modifications where an elevated fixture may not be suitable.

Figure 5.3. Taxiway Edge Lighting Configuration Entrance/Exit.



5.1.5.2. To reduce the “sea of blue lights” effect at an airfield that has many taxi routes, hoods may be used on elevated fixtures. Do not use hoods on entrance or exit light fixtures.

5.1.5.3. Where elevated lights may be damaged by jet blast or operation of an arresting gear, or where they interfere with aircraft operation, use in pavement fixtures. See Chapter 12, paragraph 12.11.1 for applicable fixtures used.

5.1.6. Power Requirements. Provide a main power system and circuits which permit independent control of the taxiways. Provide standby power only for those taxiways supporting precision instrument approaches. Transfer time from the failed power system shall not exceed 15 seconds.

5.1.7. Control Requirements. Taxiway lighting circuits shall be segmented and controlled to provide the degree of flexibility required for airfield operations. (See figure 5.4). Provide remote on/off control for all taxiway segments, and provide a three step intensity control.

5.1.8. Monitoring Requirements. There is no requirement for monitoring taxiway circuits.

5.1.9. Compliance with International Standards.

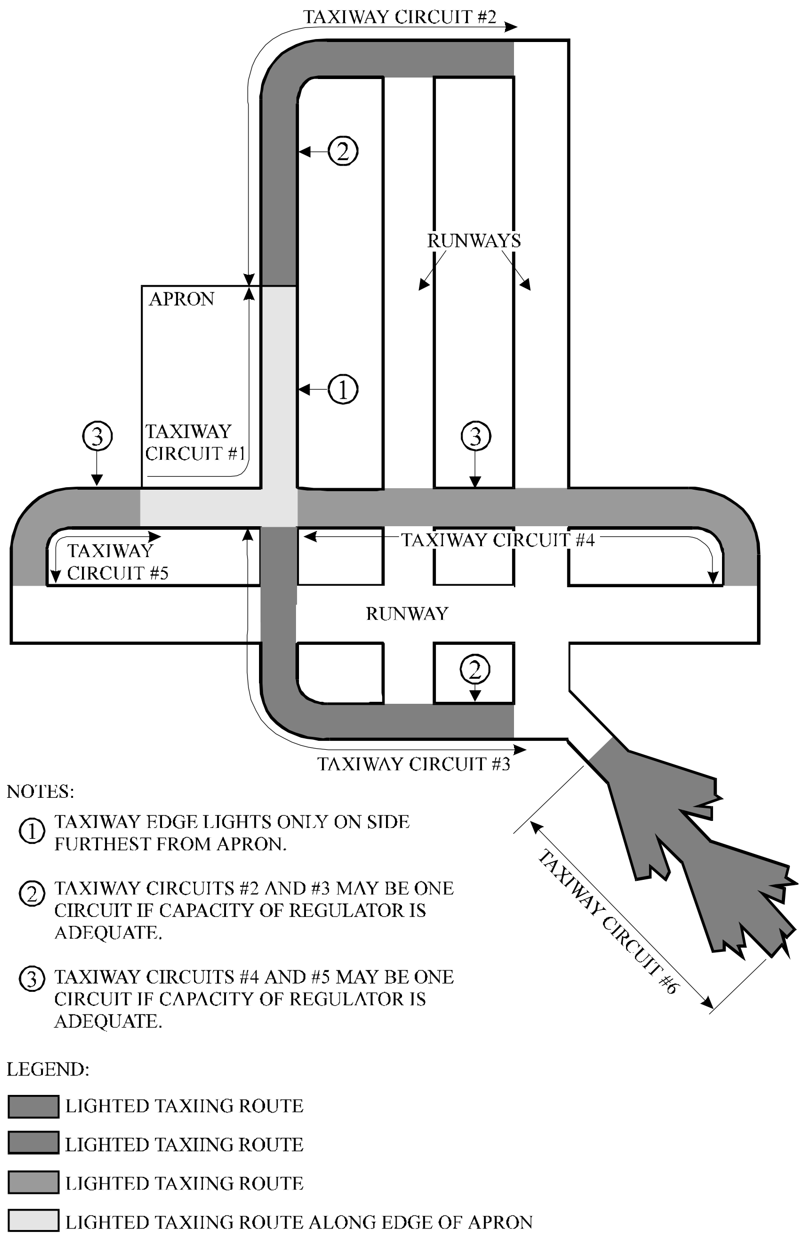
5.1.9.1. ASCC. These standards meet the requirements of AIR STD 65/35, Aerodrome Lighting, except for the light spacing on curves.

5.1.9.2. NATO. These standards meet the requirements of STANAG 3316, Airfield Lighting, except for the light spacing on curves.

5.2. Taxiway Centerline Lights:

5.2.1. Purpose. Taxiway centerline lights are a system of aviation green in pavement lights installed along the taxiway centerlines which provide alignment and course guidance information to supplement edge lighting. They may be installed where it is impractical to install taxiway edge lights. However, they are required at airfields designed for CAT II or CAT III operations on taxiways which support these operations. They are also used instead of edge lights on taxiways sections which cross aprons, ramps, or other large paved areas.

Figure 5.4. Taxiway Circuit Layout.

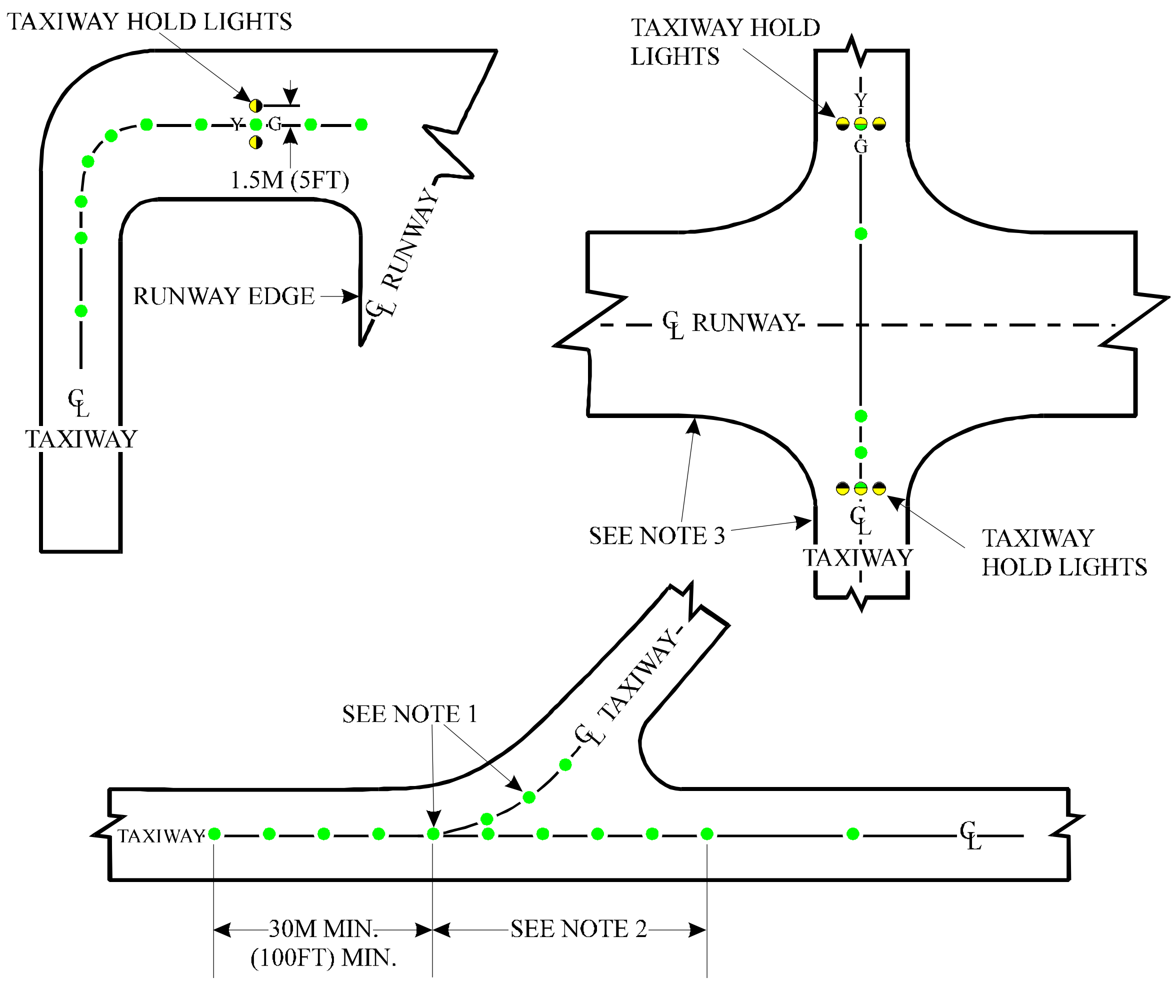


5.2.2. Configuration. Install taxiway centerline lights in smooth lines along the taxiway centerline. To avoid construction joints or markings, the line of lights may be offset uniformly a maximum of 0.6 meters (2 feet) from the centerline. Determine the light spacing as follows:

5.2.2.1. Place a light at each holding position, at each PT of a curved section, at each taxiway end, at each intersection with a runway edge or apron, and at the PTs of all fillets. Where taxiways cross, place a light at the intersection of the centerlines.

5.2.2.2. Place uniformly spaced lights between the points defined above, along all straight and curved sections of the taxiway. The uniform spacing shall approach, but not exceed, the criteria given in figure 5.5. The location of individual lights may be adjusted along the line of lights a maximum of 0.6 meters (2 feet) to avoid construction problems.

Figure 5.5. Taxiway Centerline Lighting Configuration.



LONGITUDINAL SPACING CRITERIA

		CAT. II IFR	ALL OTHER
NOMINAL		15M (50FT)	30M (100FT)
AT INTERSECTIONS (SEE NOTE 2)		15M (50FT)	15M (50FT)
CURVES	RADIUS LESS THAN 120M (400FT)	3.75M (12.5FT)	7.5M (25FT)
(SEE	RADIUS 122M (400FT) TO 360M (1200FT)	7.5M (25FT)	15M (50FT)
NOTE 1)	RADIUS GREATER THAN 360M (1200FT)	15M (50FT)	30M (100FT)

NOTES:

1. LOCATE LIGHTS AT PT1 AND PT2, AND SPACE INTERMEDIATE LIGHTS EQUALLY ALONG SELECTED CURVE IN COMPLIANCE WITH SPACING CRITERIA.
2. SPACE LIGHTS EQUALLY BETWEEN PT1 AND "HOLD" LIGHTS.
3. RUNWAY AND TAXIWAY EDGE LIGHTS NOT SHOWN.

LEGEND:

Y/G BIDIRECTIONAL, GREEN AND YELLOW

BIDIRECTIONAL, GREEN

UNIDIRECTIONAL, YELLOW

5.2.2.3. At taxiway intersections, place lights along an arc drawn tangent to the centerlines of the taxiways (or lines of lights) in the direction of all aircraft turns. Where aircraft turns are not anticipated, the arc of lights may be omitted in order to reduce confusion. The minimum clearance to the inner edge of either taxiway shall be equal to one half the width of the narrower taxiway. Select the largest radius that will provide the clearance for the arc of lights. Except as specified for runway exit lights, do not install taxiway centerline lights on runway surfaces.

5.2.3. Tolerances. Taxiway centerline lights shall not be more than 0.07 meters (3 inches) off of the designated line of lights and not more than 0.15 meters (6 inches) from the designated locations along the line of lights.

5.2.4. Equipment. (See Chapter 12, paragraph 12.11.2). Use in pavement fixtures which do not protrude more than 0.01 meters (0.50 inch) above the pavement. They shall be bi-directional aviation green except as follows:

5.2.4.1. At crossing taxiways, the light at the intersection shall be omni-directional aviation yellow.

5.2.4.2. On taxiways where the aircraft movement is in one direction only, the lights may be uni-directional facing the oncoming aircraft.

5.2.4.3. Where hold lights are installed, the centerline light shall be aviation yellow facing the holding aircraft.

5.2.5. Photometric Requirements. Taxiway centerline lights shall be bi-directional and emit aviation green light at three intensity steps: 100 percent, 30 percent, or 10 percent of full brightness. The minimum intensities and beam widths are shown in table 5.1.

Table 5.1. Taxiway Centerline Light Intensity and Beam Widths.

	AVERAGE	---------------- BEAM WIDTH ----------------			
	INTENSITY	50% OF MAIN		10% OF MAIN	
	OF	BEAM AVERAGE		BEAM AVERAGE	
APPLICATION	**MAIN BEAM**	**HOR.**	**VERT.**	**HOR.**	**VERT.**
CAT II and Higher					
Straight	20 cd	± 10	1 to 4	± 16	0.5 to 10
Curved	20 cd	± 30	1 to 4	± 30	0.5 to 10
CAT III					
Straight	200 cd	± 3.5	1 t 8	± 4.5	0 to 13
Curved	100 cd	± 30	1 to 10	± 30	0 to 15

5.2.5.1. Horizontal Aiming. Aim lights on straight sections parallel with the taxiway centerline. Aim lights on curved sections along the tangent at the light location.

5.2.6. Power Requirements. Provide a main power system and circuits which permit independent control of the taxiways. Provide standby power only for those taxiways essential for precision instrument approaches. Transfer time from the failed system to standby system shall not exceed 15 seconds.

5.2.7. Control Requirements. Provide remote on and off and three step intensity control. The system may be segmented to provide flexibility in choosing taxiway routing.

5.2.8. Monitoring Requirements. There is no monitoring requirement for taxiways.

5.2.9. Compliance with International Standards.

5.2.9.1. ASCC. These standards meet the requirements of AIR STD 65/35, Aerodrome Lighting.

5.2.9.2. NATO. These standards meet the requirements of STANAG 3316, Airfield Lighting, except for the light spacing on curves.

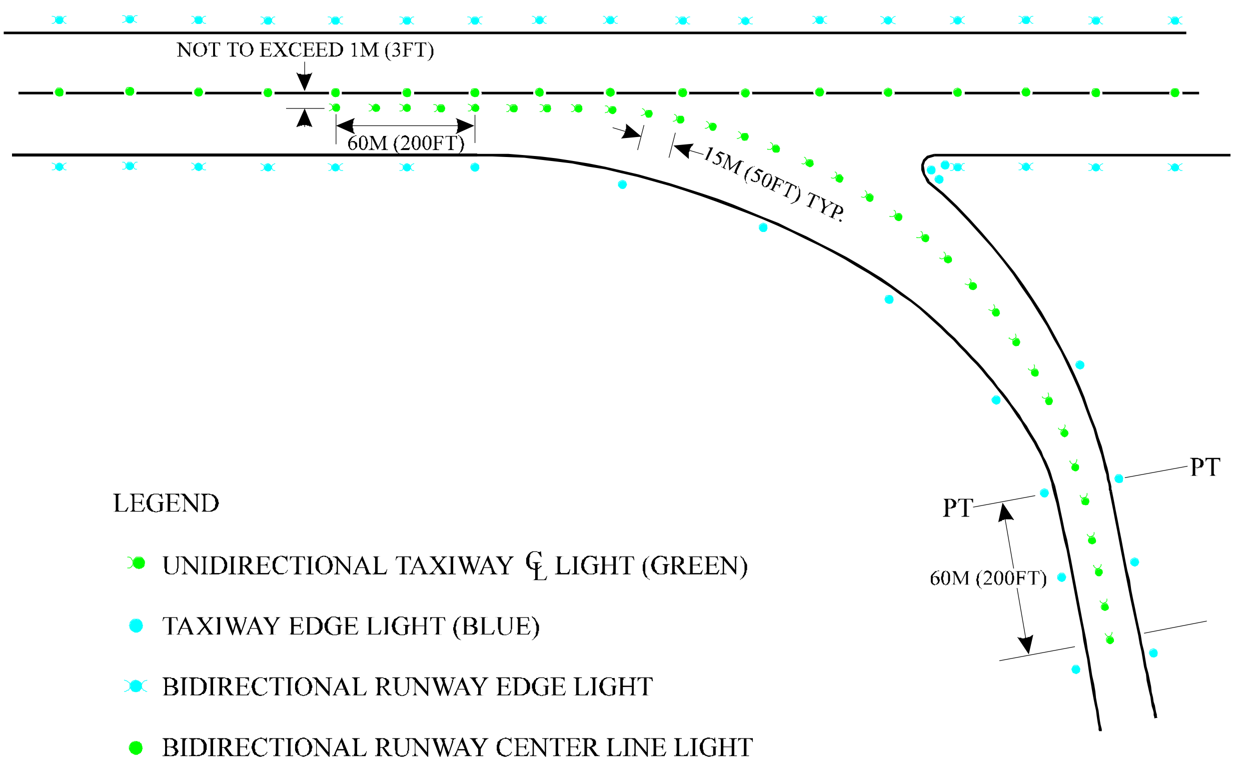
5.3. Runway Exit Lights:

5.3.1. Purpose. Runway exit lights may be added to long radius (high speed) exit taxiways, or to short radius (low speed) taxiway exits where there is a need to expedite movement of aircraft off the runway. Runway exit lights may be installed with either taxiway edge or taxiway centerline lights.

5.3.2. Configuration:

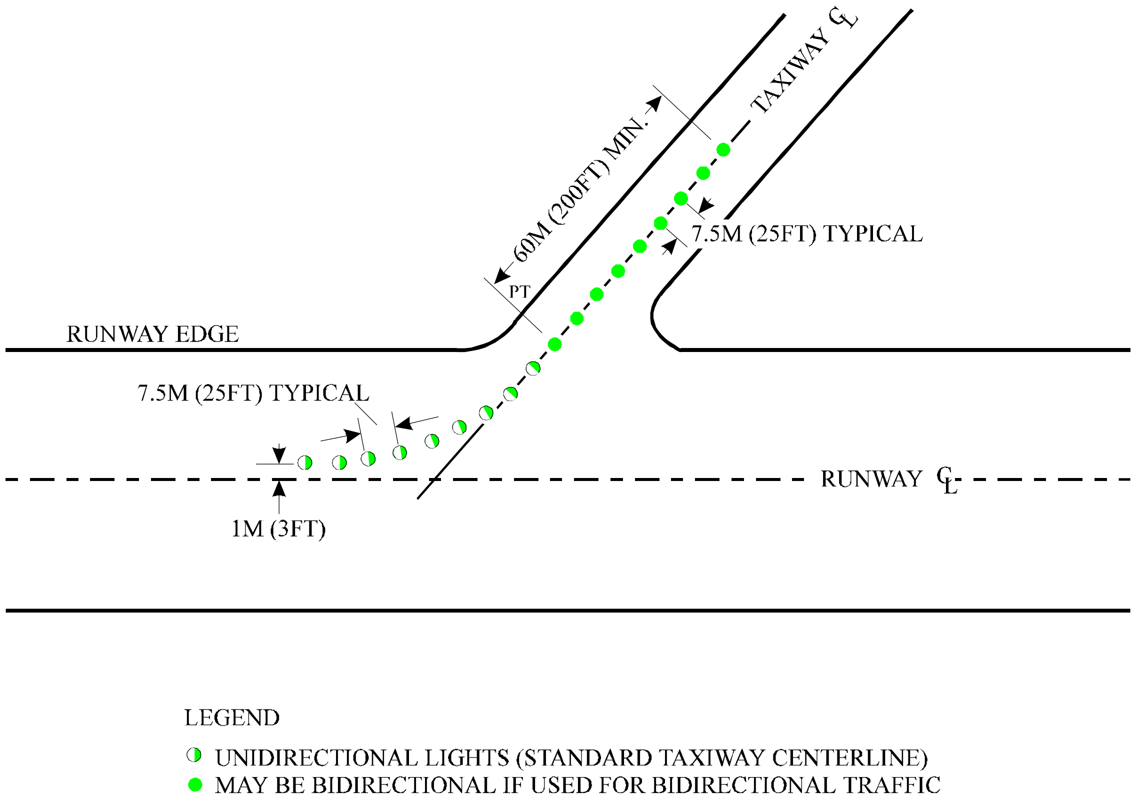
5.3.2.1. Long Radius Exits. Long radius exit lights are installed on exits with radii exceeding 360 meters (1,200 feet). They consist of a line of uni-directional green taxiway centerline lights. The line begins at a point which is a maximum of 1 meter (3 feet) off the runway centerline and 60 meters (200 feet) before the beginning of the taxiway centerline curve. The line of lights runs parallel to the runway to the beginning of the taxiway centerline curve. It then follows the taxiway centerline curve to a point which is a minimum of 60 meters (200 feet) beyond the beginning of the straight portion of the taxiway. The lights are uniformly spaced at a distance of not more than 15 meters (50 feet). (See figure 5.6).

Figure 5.6. Taxiway Long Radius High Speed Exit Lights.



5.3.2.2. Short Radius Exits. Short radius exit lights consist of a line of green taxiway centerline lights. The line of lights begins at a point which is not more than 1 meter (3 feet) off the runway centerline on the near side and is the PT of the exit curve. The radius of the curve should be the largest that will provide a minimum clearance to the pavement edge equal to one half the width of the taxiway. The line of lights runs along the arc to the PT with the taxiway centerline. It then follows the taxiway centerline for a minimum of 60 meters (200 feet). The spacing between the lights is not greater than 7.5 meters (25 feet). (See figure 5.7).

Figure 5.7. Taxiway Short Radius High Speed Exit Lights.



5.3.3. Adjustments and Tolerances. The requirements in paragraph 5.2.3 for taxiway centerline lights apply.
5.3.4. Photometric Requirements and Horizontal Aiming. The requirements in paragraphs 5.2.5 for taxiway centerline lights apply.
5.3.5. Equipment. Use uni-directional, in pavement fixtures with no part extending more than 0.01 meters (0.5 inch) above the surrounding pavement. (See Chapter 12, paragraph 12.11.2).
5.3.6. Power Requirement. Provide a main power supply and circuits which permit independent control except on a taxiway with centerline lighting. In this case, they may be connected to and controlled with the taxiway centerline lights.
5.3.7. Control Requirement. Provide remote on/off and intensity control. Runway exit lights may be controlled with associated taxiway centerline lights.
5.3.8. Monitoring Requirements. There are no monitoring requirements.
5.3.9. Compliance with International Military Standards:
5.3.9.1. ASCC. These standards meet AIR STD 65/35, Aerodrome Lighting.
5.3.9.2. NATO. These standards meet NATO STANAG 3316, Airfield Lighting.

5.4. Taxiway Hold Lights/Stop Bar:
5.4.1. Purpose. Taxiway hold lights are installed at hold positions where there is a need to enhance identification.
5.4.2. Configuration. They consist of 3 in pavement lights spaced 1.5 meters (5 feet) apart. They are installed symmetrically about the taxiway centerline within three feet of the hold position markings. (See figure 5.5). The number of lights may be increased to five if the hold position is unusually wide.

5.4.3. Equipment. Use in pavement fixtures with no part extending more than 0.01 meters (0.50 inch) above the surrounding pavement. Hold lights shall emit uni-directional aviation yellow light toward the holding aircraft. When installed with taxiway centerline lights, the center light shall be bi-directional aviation yellow/green with the yellow light toward the holding aircraft.
5.4.4. Photometric Requirements. Hold lights shall emit aviation yellow light. All other photometric requirements in paragraph 5.2.5 for straight section taxiway centerline lights apply.
5.4.5. Fixtures. Power and Control Requirements. The requirements for taxiway centerline lights apply. Fixtures shall be powered and controlled by the associated taxiway lighting system.
5.4.6. Monitoring. There is no requirement for monitoring.
5.4.7. Compliance with International Military Standard. ASCC and NATO Standards contain no comparable systems.

5.5. Hold Position Edge Lights (Wig-Wag) (Runway Guard Lights):
5.5.1. Purpose. Hold position edge lights are used where hold markings, signs, and clearance markings have not been fully effective, or in areas where other lights might cause distraction. They are installed to emphasize the need for caution and use of safety procedures.
5.5.2. Configuration. The installation consists of a light fixture placed on each side of the taxiway at the hold position line. The fixtures shall be located in a line with the holding position and the hold position markers on each side of the taxiway. The fixtures shall be placed as close as possible to the taxiway edge as permitted by height clearances, but not less than 10.5 meters (35 feet), and not less than 0.9 meters (3 feet), from the outside edge of the hold position markers. The height shall not be more than 0.76 meters (2.5 feet) above the adjacent taxiway pavement edge. The fixtures shall be aimed horizontally with the center of the light beams to intercept the taxiway centerline 30 meters (100 feet) before the actual hold position. Vertically, the center of the beams should be aimed at 10 degrees above horizontal.
5.5.3. Equipment. The hold position edge lights (Wig-Wag) fixtures shall be installed on light bases, or on conduit set in concrete foundations, using frangible supports. The transformers, or power supply unit may be placed in the same light fixture base. The light emitted shall be aviation yellow, and alternately flash 50 to 60 times per minute. The illumination period of each flash shall not be less than 1/2 or more than 2/3 of the total cycle. See figure 12.22 for a typical fixture.
5.5.4. Power, Control and Monitoring. The electrical power for the Wig-Wag lights shall be provided by the associated taxiway edge or centerline lights. The intensity control may be from the taxiway light circuit, or by photoelectric switch. The lowest intensity shall not be less than 30 percent of the rated intensity. There is no monitoring requirement.
5.5.5. Compliance With International Standards. The ASCC and NATO standards do not contain comparable systems.

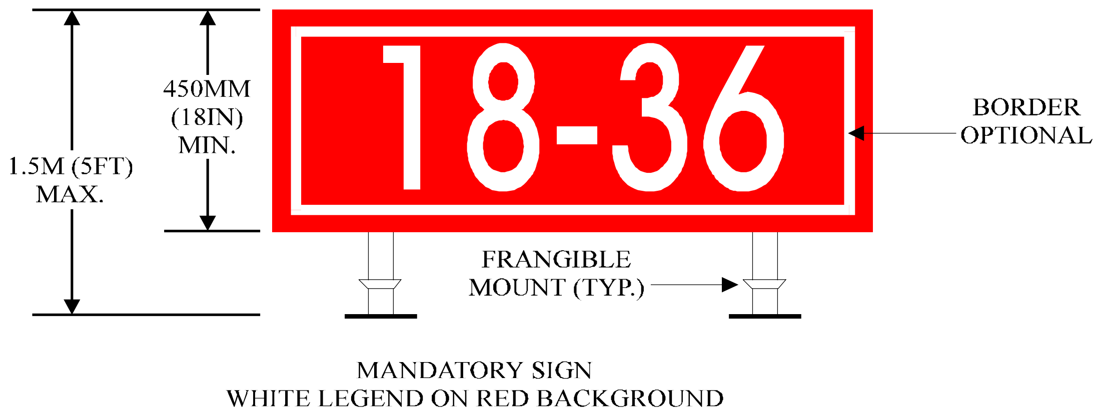
5.6. Taxiway Guidance Signs:
5.6.1. Purpose. Taxiway guidance signs aid aircraft pilots to destinations and provide ground control of aircraft and safety of ground operations. The extent of guidance and control provided depends on the complexity of the airfield layout, volume of traffic, and visibility. For additional guidance see FAA AC 150/5340-18 and AC 150/5345-44.
5.6.1.1. Airports with complex layouts require more precise taxiing and control guidance since the pilot must make more decisions in choosing the proper destination route. Also, there is a greater possibility of collision at intersections with other aircraft. Traffic volume alone may justify signs to promote safe taxiing.
5.6.1.2. As traffic increases, more signs are needed to simplify and reduce the amount of information that must be transmitted by radio. Regardless of the complexity of the airport layout or the amount of the

traffic volume, signs are required to provide the necessary guidance and to insure safe operations when visibility is poor.

5.6.2. Sign Classifications. Signs provide various types of information to pilots and are classified as either mandatory or informative:

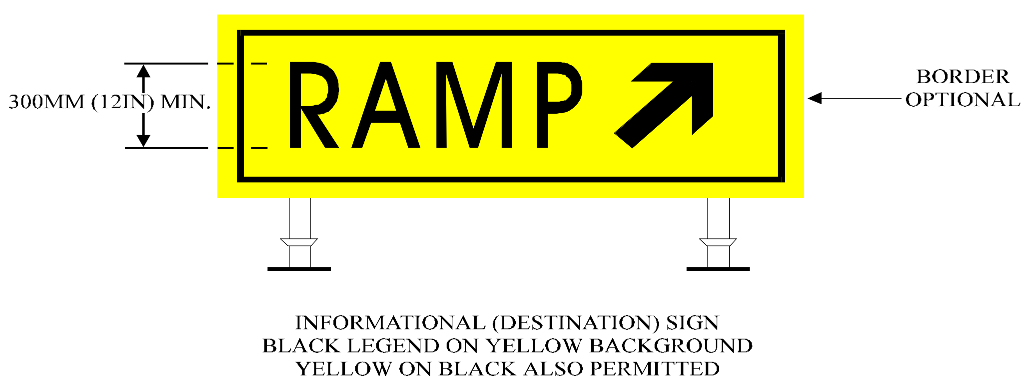
5.6.2.1. Mandatory Signs. A mandatory sign is provided when an instruction must be followed, such as at instrument or runway hold positions. Typical mandatory signs are stop signs, no-entry signs, holding position signs, and taxiway or runway intersection signs when used instead of a stop or holding position sign. A mandatory sign has a white inscription on a red background. (See figure 5.8).

Figure 5.8. Taxiway Guidance Signs (Mandatory).



5.6.2.2. Informative Signs. All non-mandatory signs are classified as informative signs. They are used as necessary to indicate a specific location, or destination on an aircraft movement area, or to provide other useful information. This sign has either a black inscription on a yellow background, or a yellow inscription on a black background. (See figure 5.9).

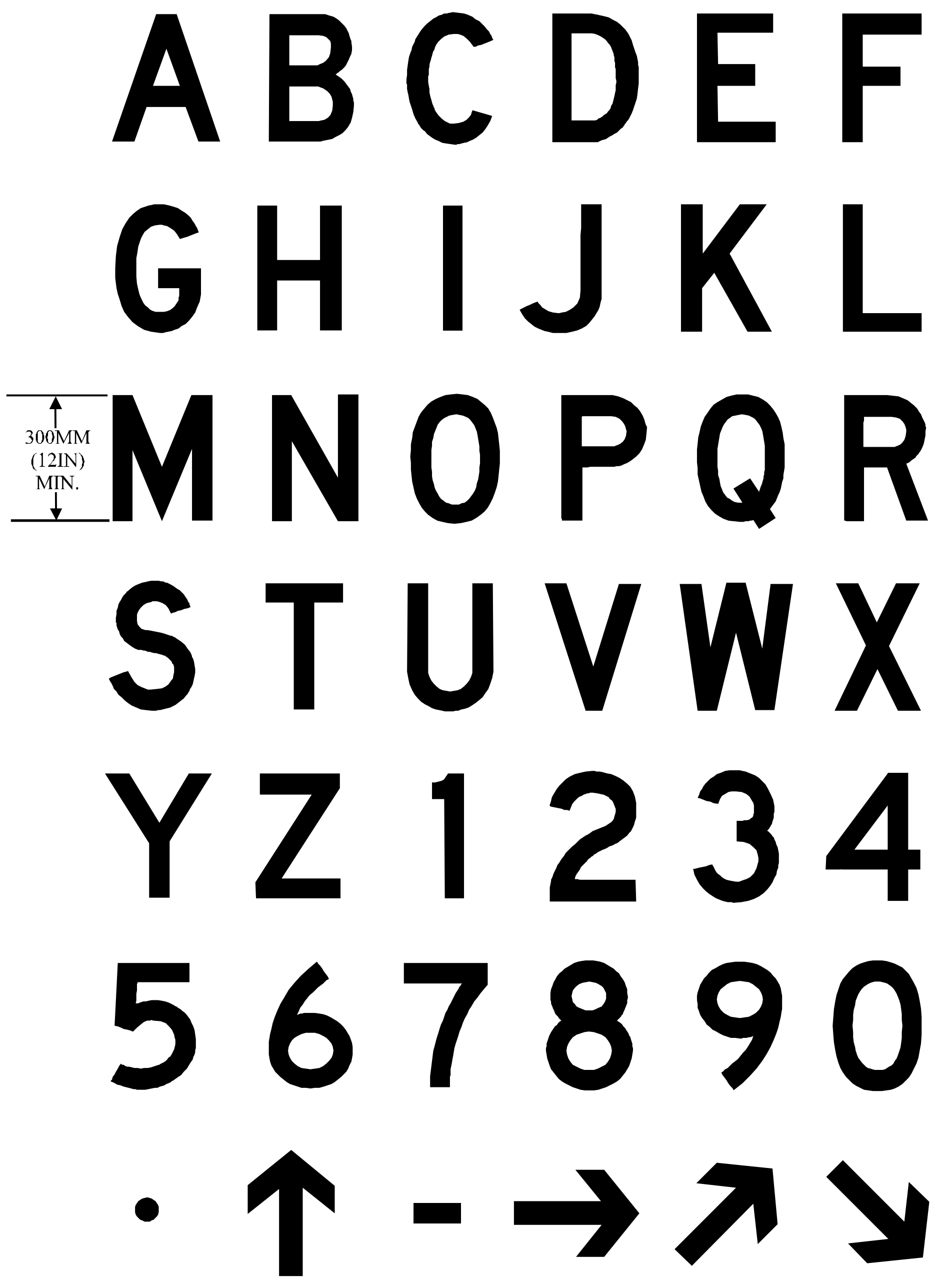
Figure 5.9. Taxiway Guidance Signs (Informational).



5.6.3. Sign Configurations:

5.6.3.1. Standard Guidance Signs. Taxiway guidance signs supporting night and instrument operations shall be internally illuminated. They may be single or double-faced. Marking and illumination shall be sufficient to make the sign readily discernible under the following conditions: at night from a distance of 240 meters (800 feet), and under a meteorological visibility of 900 meters (3,000 feet) from a minimum distance of 150 meters (500 feet) day or night. Color schemes for signs shall be as specified in paragraph 5.5.2. Standard Air Force taxiway guidance signs shall be a minimum of 0.45 meters (18 inches) high with a legend height of 0.3 meters (12 inches). Legend characters shall be as shown in figure 5.10. The length of the sign is determined by the number of characters required for the message. The signs may be fabricated as a single unit or in sections. Mount signs with an overall height of no more than 0.6 meters (24 inches) above the adjacent taxiway surface. Offset them from the taxiway edge between 7.5-10.5 meters (25-35 feet). Install signs which are mounted more than 0.75 meters (30 inches) above the taxiway surface at least 10.5 meters (35 feet) from the taxiway edge. In no case shall the overall mounting height be more than 1.5 meters (5 feet) above the ground at the sign location. All signs shall be frangible mounted.

Figure 5.10. Sign Typical Letter, Numerals, and Symbols.



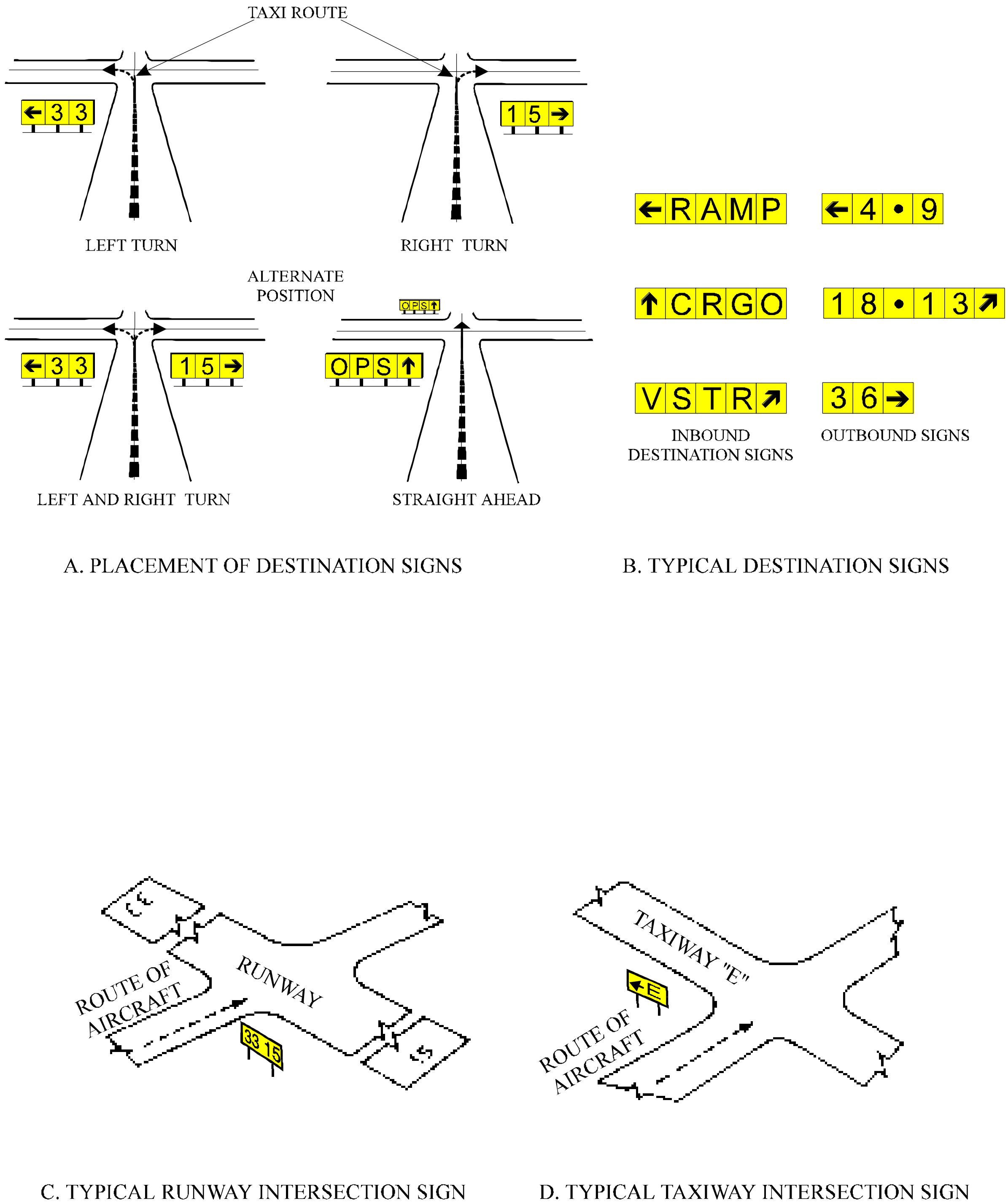
5.6.3.2. Nonstandard Signs. Special circumstances may dictate that a standard sign is unsuitable for a particular sign location. In this case, follow the guidelines contained in FAA Advisory Circulars AC 150/5345-44 and AC 150/5340-18.

5.6.4. Taxiway Guidance System Configuration. There are no standard configurations for taxiway guidance systems. Before designing a taxiway guidance sign system, make a thorough study of the taxiway layout drawings with local traffic controllers and the operational groups using the airfield. Keep the number of signs to a minimum since they are possible hazard to aircraft:

5.6.4.1. Destination Signs:

- General. Provide destination signs where required for both inbound and outbound taxiing routes as shown in figure 5.11.

Figure 5.11. Taxiway Sign Locations.



- Outbound Destination Signs. Mark outbound routes from their beginning to their termination point with destination signs showing the appropriate runway numbers. Outbound routes usually begin at the entrance of a taxiway from an apron area; its termination point is the takeoff end of the appropriate runway. Outbound destination signs may show more than one runway destination number if the direction of travel on a taxiing route is the same to all the runway destinations shown on the sign. In such cases, separate any pair of runway destination numbers by a circular dot.

- Inbound Destination Signs. Mark inbound routes from their beginning with destination signs showing the appropriate symbols. Inbound routes usually begin at the entrance to a taxiway from a runway. Mark inbound traffic routes at the beginning with destination areas on an airport. Provide destination signs giving directions to specific areas at appropriate intersections along the inbound traffic route. Typically, signs installed at the entrance to a taxiway from a runway show "RAMP," "E RAMP," "MIL," etc. Install destination signs at other locations along the inbound traffic routes and in the vicinity of the general destination area with symbols showing the direction to specific areas, such as "GATE 3," "VSTR," etc. This requirement is a general guide and may be varied as necessary due to local conditions, variations in airport layout and ground traffic conditions.

5.6.4.2. Intersection Signs:

- General. Provide intersection signs with appropriate numbers or letters at the intersections of runways, taxiways, or taxiways with an apron. They inform the pilot of an approaching intersection and identify the intersecting operational surface. (See figure 5.11).
- Runway Intersection Signs (Mandatory). On runway intersection signs, provide the numbers and letters assigned to each end of a runway to identify an intersecting runway. Separate the assigned numbers and letters shown on the intersection sign by a dash, such as "33-15." Indicate, by the arrangement of the runway numbers on the sign, the direction to the corresponding ends of the runway. For example, "33-15" indicates to the pilot that the "33" end of the runway is to the left, and the "15" end of the runway is to the right. (See figure 5.11).
- Taxiway Intersection Signs (Mandatory). Use letters to identify taxiways. Use the same letters to identify an entire taxiway, even if it is composed of short sections caused by intersections of other taxiways or runways. Use double letters such as "AA" to identify taxiways on an airport with more taxiways than there are single letters. (See figure 5.11).
- Alternate Routes. At intersections or junctions of runways, taxiways, or runways and taxiways, where there are alternate routes to a particular destination from a given direction of travel, the destination sign shall indicate only one route. (See figure 5.12).

5.6.4.3. Holding Position signs (Mandatory). Holding positions are usually either instrument holding positions or runway holding positions and are marked as specified in AFJMAN 32-1015. Identify instrument holding positions with a holding position sign using the letters "INST." Identify runway holding positions with runway intersection signs. Signs marking holding positions are mandatory signs.

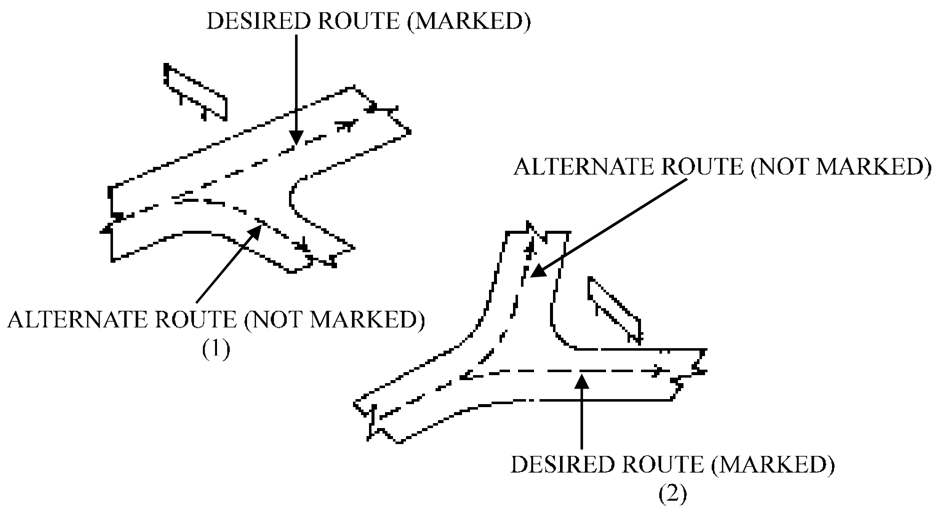
5.6.5. Sign Locations:

5.6.5.1. General Information. Due to the variety of taxiway intersections and information which may be required, providing a firm rule for the location of signs is difficult. A good general practice is to locate intersection signs on the near side of intersections. Place a sign indicating a destination on the far side of the intersection and on the same side of the taxiway as the direction to the destination indicated. If the destination is straight ahead, the sign may be located on either side. (See figure 5.13).

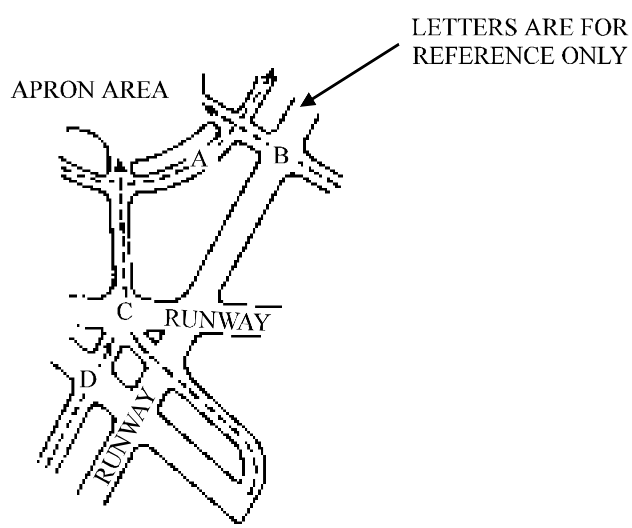
5.6.5.2. Holding Position Signs (Mandatory). Install signs at either or both ends of a critical or obstacle clearance area adjacent to the hold line marking. When the hold line marking exceeds 45 meters (150 feet) in length, a sign shall be placed at each end of the hold line marking. Signs may be required adjacent to runways to identify the critical or obstacle clearance areas since critical area hold line markings are not provided across usable runways. Holding position signs shall be installed when the runway is used as a taxiway or is approved for simultaneous operations with an intersecting runway. (See figure 5.13).

5.6.6. TACAN Checkpoint Signs. The TACAN checkpoint signs shall be provided when an airfield has a TACAN system and provides information for the pilot who is verifying the operation of the navigational aid in the aircraft before takeoff. For location of the TACAN checkpoint, see figure 5.14. The sign shall include the type of navigational aid, identification code, radio channel, magnetic bearing, and the distance in nautical miles to the transmitting antenna from the checkpoint marking. The character height shall be not less than 0.15 meters (6 inches) or more than 0.22 meters (9 inches) high and the stroke width not less than 0.02 meters (1 inch). The sign should have black characters on a yellow background and shall be similar in shape and color when lighted at night and unlighted in daytime. Other contrasting colors are permitted. The signs may be either internally or externally illuminated with uniform brightness. The height of the sign shall be not more than 0.8 meters (32 inches) and the length not more than 1.8 meters (72 inches), however, the elevation at the top shall not exceed 1 meter (40 inches) above the taxiway edge elevation and shall not be located less than 15 meters (50 feet) from the taxiway edge. A typical sign is shown in figure 5.15.

Figure 5.12. Alternate Taxiway Routes.



ALTERNATE ROUTES



ASSINGMENT OF LETTERS TO TAXIWAYS

Figure 5.13. Typical Locations and Siting of Taxiway Signs.

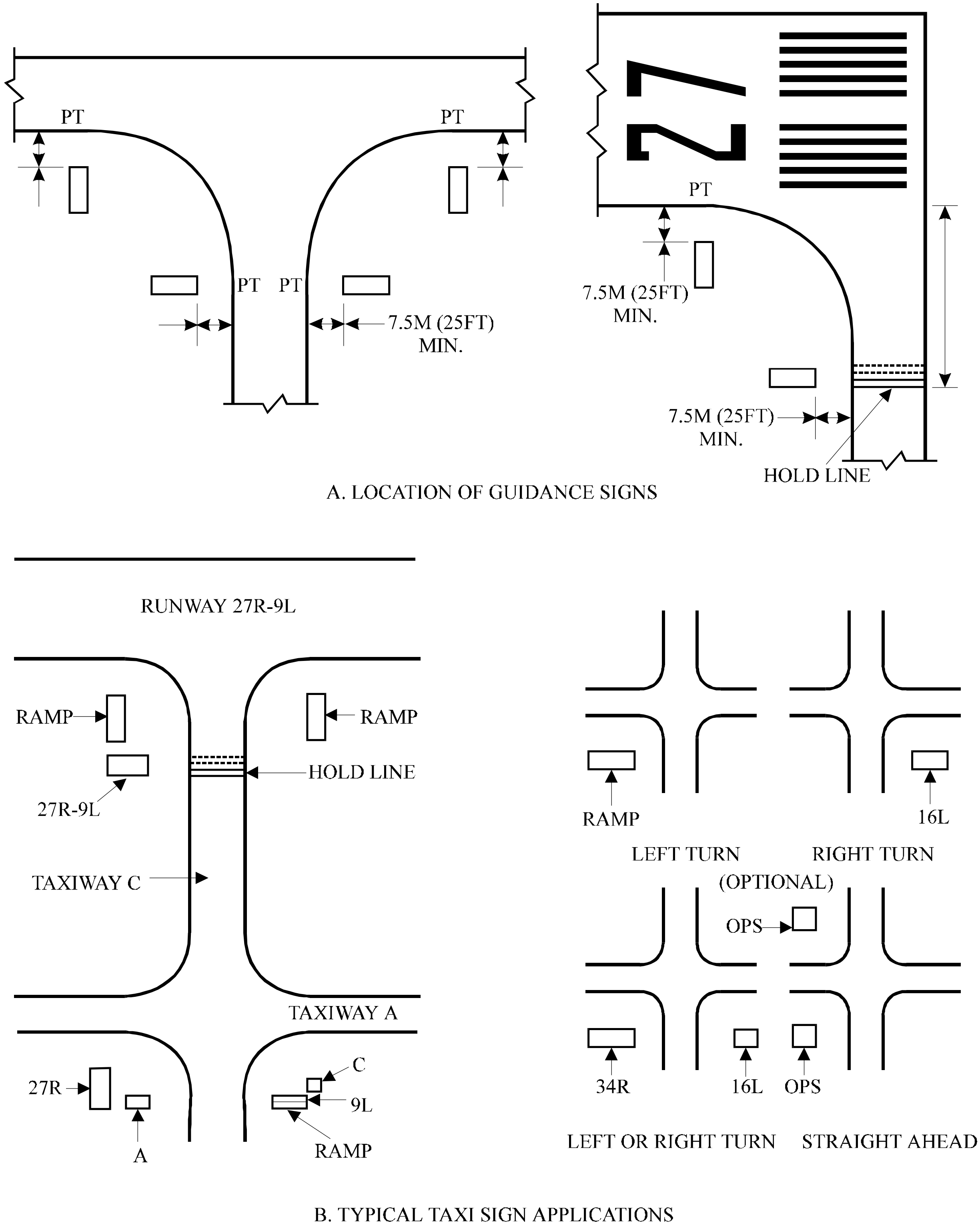


Figure 5.14. TACAN Sign Location.

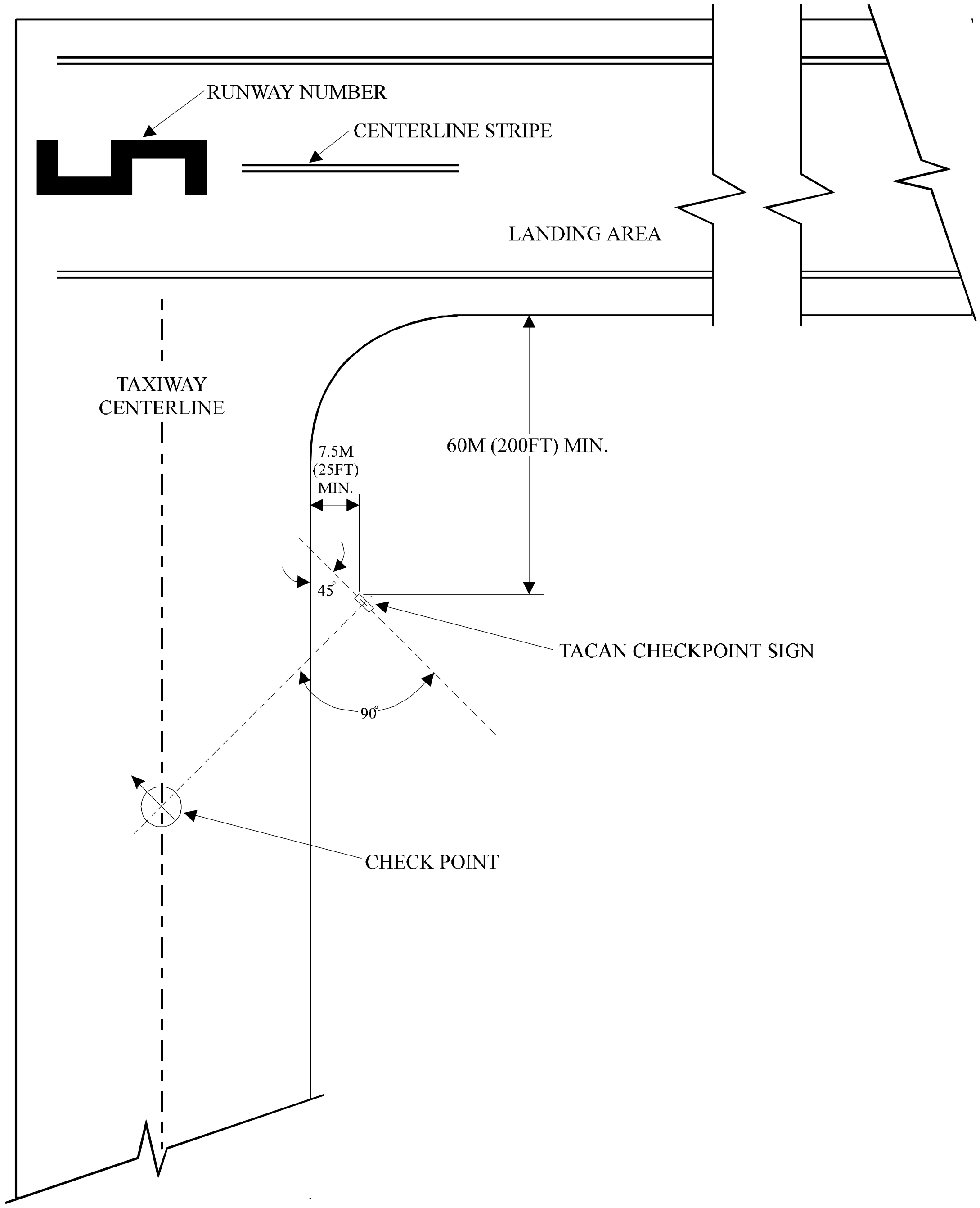
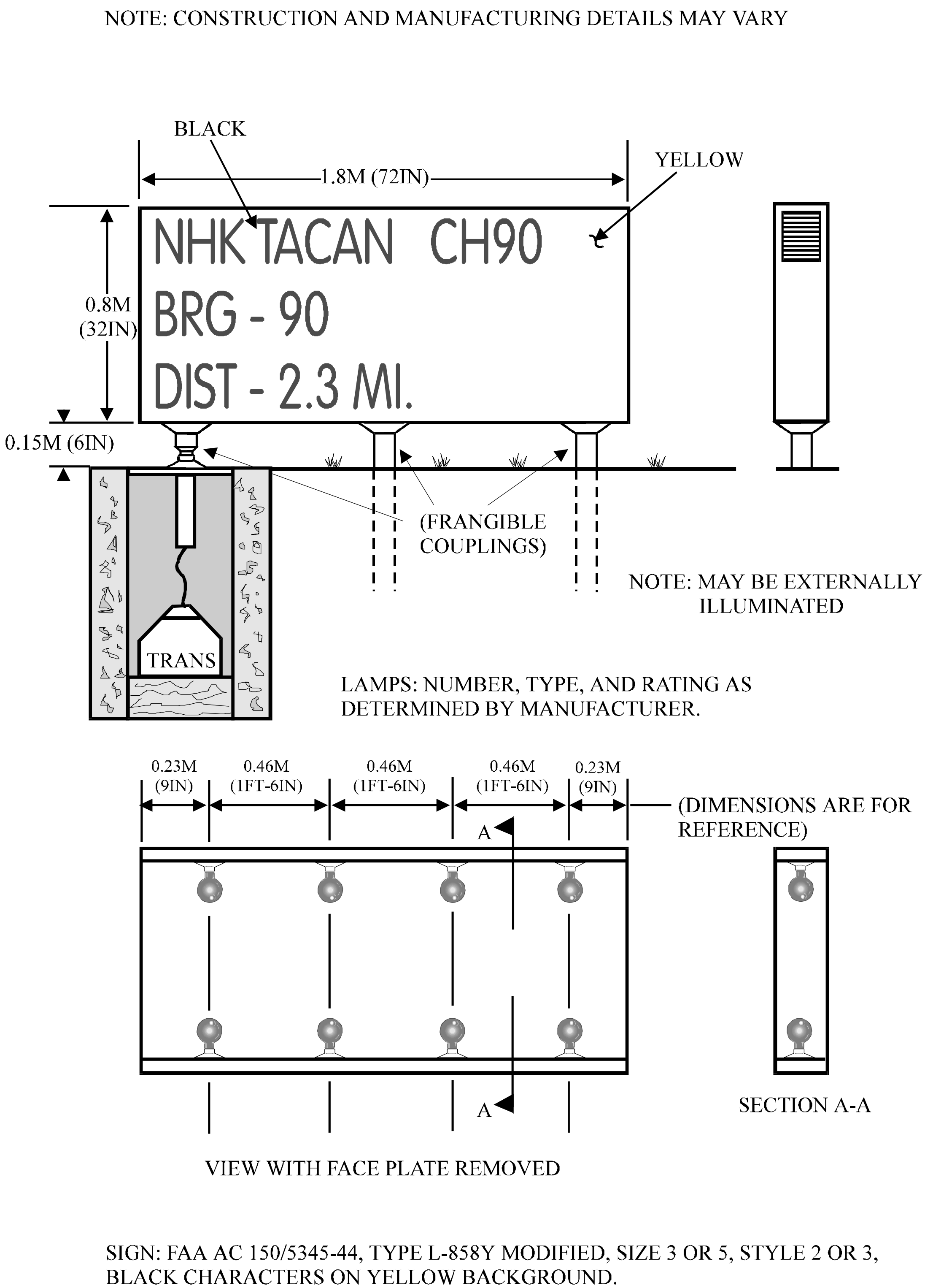


Figure 5.15. Typical TACAN Sign.



5.6.7. Power and Control. Taxiway guidance signs are usually connected to and controlled with the associated taxiway lighting circuits. Where intensity controls are used on taxiways, provision must be made for the signs to operate at a minimum of 80 percent of the maximum brightness for each intensity setting of the taxiway lights. Hold signs may be independently powered and controlled or may be connected to the associated runway edge lighting to avoid unnecessary holding when the runway is not in operation.

5.6.8. Monitoring. There is no requirement for monitoring.

5.6.9. Compliance with International Military Standards:

5.6.9.1. ASCC. These standards meet the requirements of AIR STD 65/35, Aerodrome Lighting, Part Three, except for the location of signs at intersections.

5.6.9.2. NATO. These standards meet NATO STANAG 3316, Airfield Lighting, for taxiway signs, except for minimum size of signs and the location of some signs at intersections.

5.6.10. Altimeter Check Point Sign. When runway end elevations differ by 25 feet from the published field elevations, an “Altimeter Check Point Sign” is required. Coordinate with TERPS to verify runway and field elevations. This sign should be combined and/or colocated with the TACAN Check Point Sign when available, as the same height and lettering requirements apply. Lettering may be abbreviated as follows: “ALT CHK PT - ELEV: XXXX.”

Chapter 6

STANDARDS FOR OBSTRUCTION LIGHTING

6.1. Purpose. Obstruction lighting defines the vertical and horizontal limits of natural or manmade objects which are considered a hazard to air navigation. Typical examples of various obstruction lighting arrangements are shown in figures 6.1 through 6.4.

6.2. Objects to be Lighted. Objects that penetrate the planes and surfaces defined in AFJMAN 32-1013 are hazards to air navigation and shall have obstruction lights installed. Other objects, which are hazards due to their nature or location even though they do not penetrate the planes and surfaces, as defined above, shall also be lighted. Construction or objects which may impact navigable airspace under the provisions of FAR Part 77 are also subject to the administrative procedures in FAA Advisory Circular AC 70/7460-1, Obstruction Marking and Lighting, for determining obstruction marking and lighting requirements.

6.3 Lighting Configuration. The number and arrangement of obstruction lights shall ensure unobstructed visibility of one or more lights from an aircraft at any normal angle of approach. Arrange obstruction lights as specified in AC 70/7460-1.

6.4. Lighting Versus Day Marking. Flashing white obstruction lighting may be used instead of obstruction marking on structures less than 60 meters (200 feet) tall with MAJCOM approval. Do not install these lights in clear zones or on objects in the immediate vicinity of runways where approaching pilots may mistake them for other flashing white lights.

6.5. Waivers. Except for projects subject to the provisions of FAR Part 77, the MAJCOM may waiver the requirements of this chapter. (See Chapter 1, paragraph 1.8).

6.6. Equipment. For various obstruction light fixtures see Chapter 12, paragraph 12.13. The equipment shown meets the requirements of the FAA.

6.7. Power Requirements. Depending on the equipment installed, the power may be from a series circuit or 120 volt multiple circuit. For flashing lights the power is usually 120 volts. Emergency power is not a requirement but is desirable if readily available.
6.7.1. Intensity Requirements. See table 6.1 for required intensity levels.

Figure 6.1. Obstruction Light Configuration, Height up to 350 Feet.

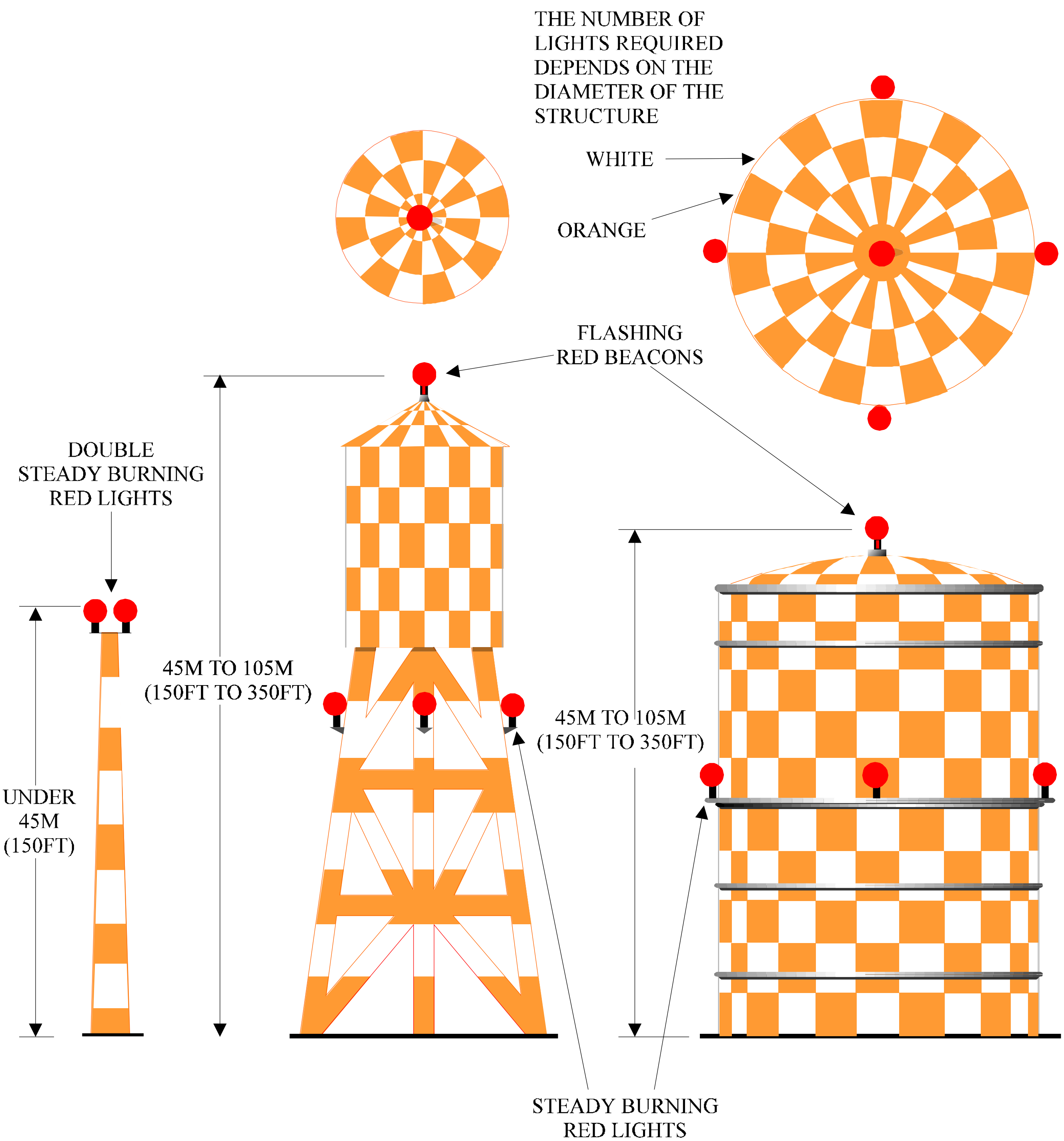


Figure 6.2. Obstruction Light Configuration, Height 150 to 350 Feet.

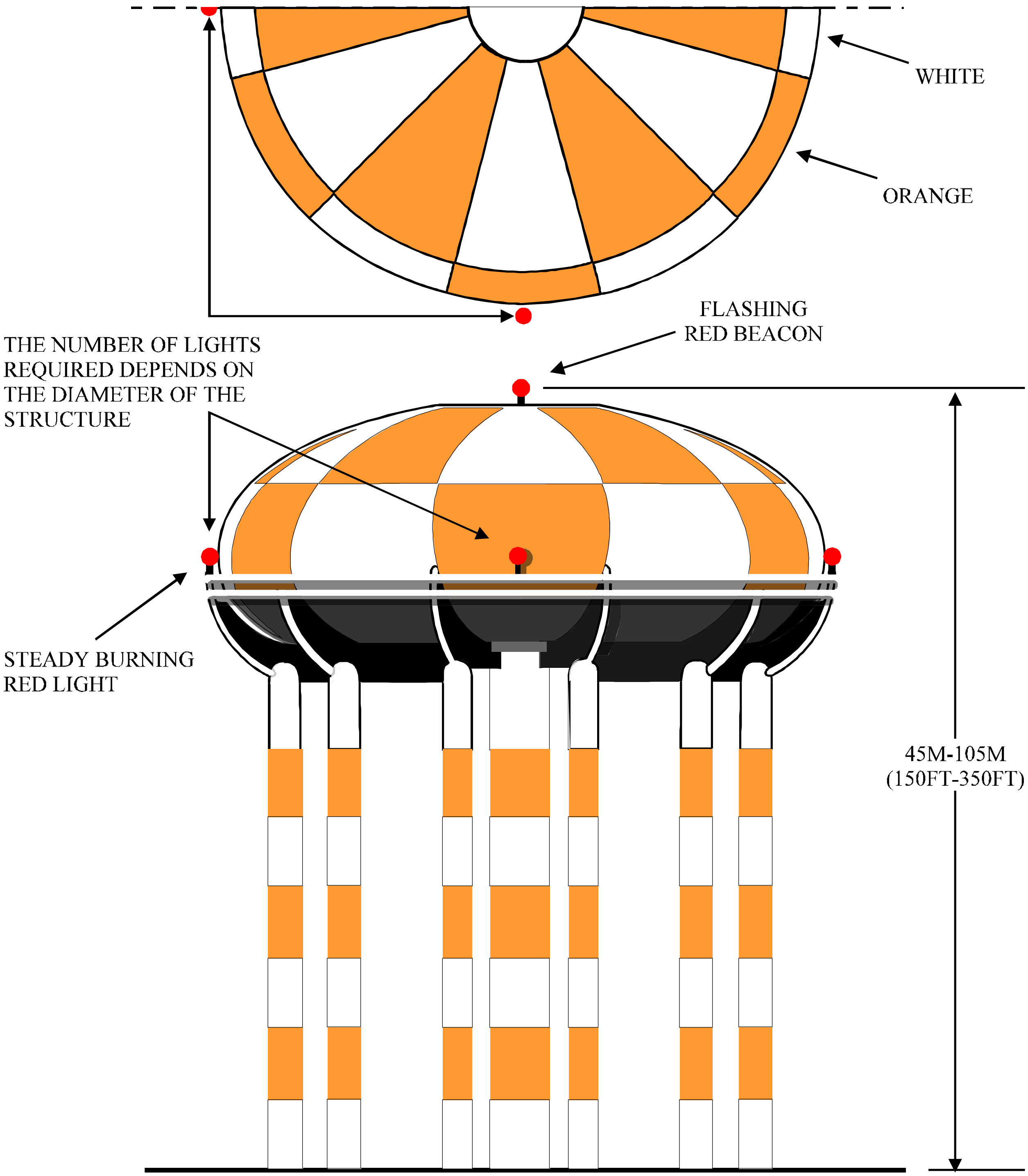


Figure 6.3. Obstruction Light Configuration, Height 350 to 700 Feet.

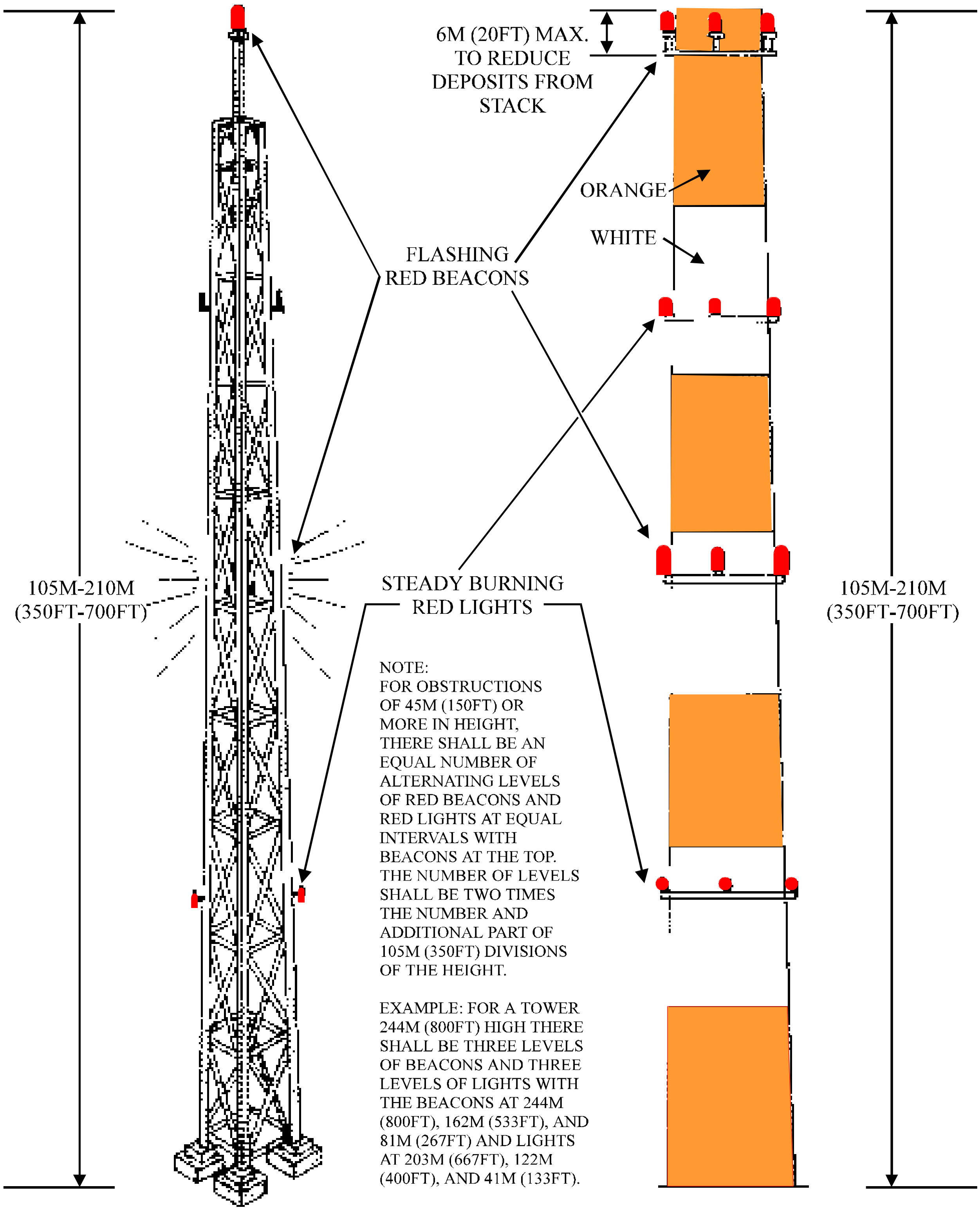
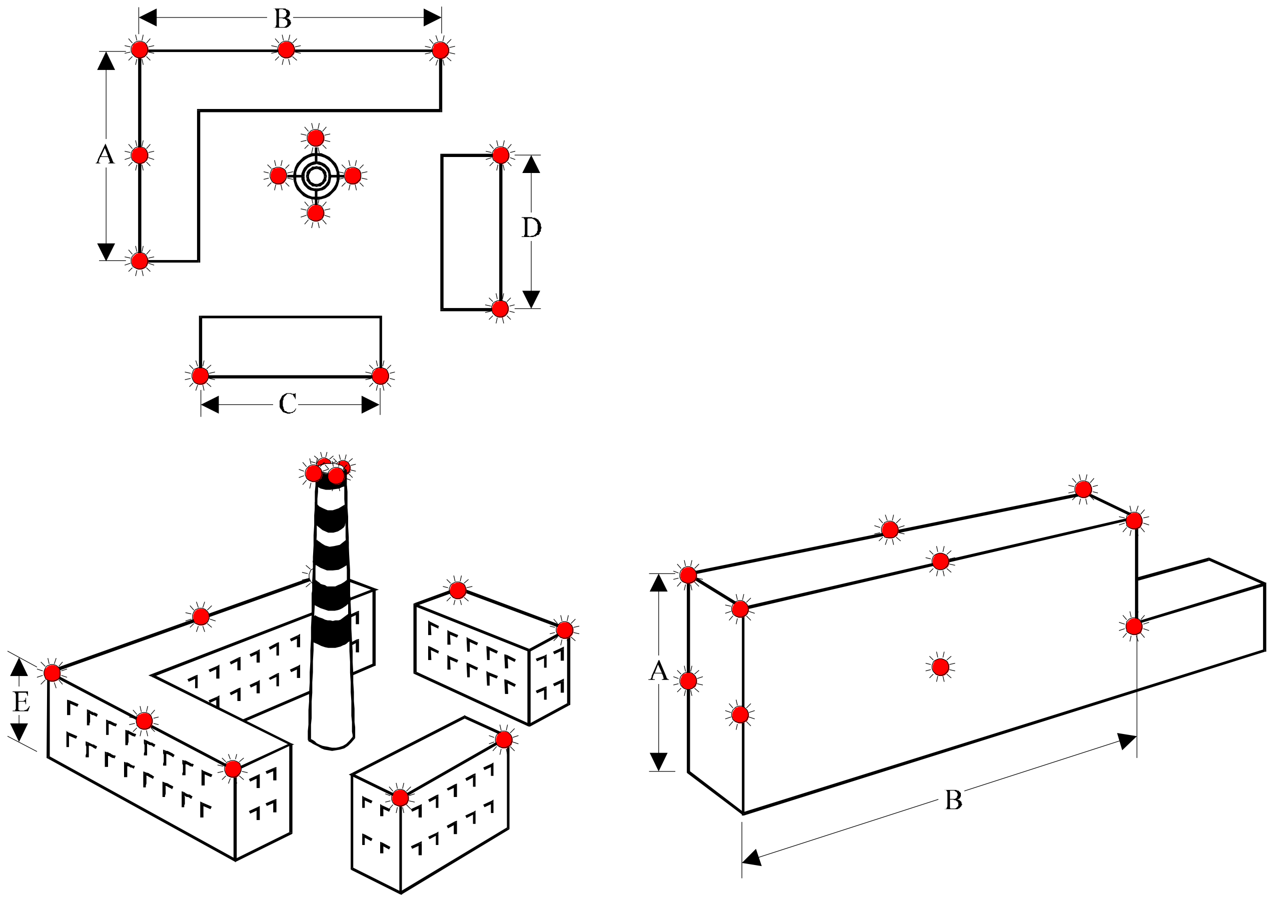


Figure 6.4. Obstruction Lights on Buildings.



A,B = 45M - 90M (150FT - 300FT)
C,D,E < 45M (150FT)

Table 6.1. Required Effective Intensities of Obstructions Lights.

Intensity step	Minimum Beamspread Vertical (degrees)	Minimum Horizontal (degrees)	Intensity Peak (candelas)
	Steady-burning red lights		
Full	10	360	30-150
	Flashing red beacon, medium intensity		
Full	3	360	2,000 ± 25%
	Flashing red beacon, rotating		
Full	10	360	20,000 min.
	Flashing white beacons, medium intensity		
Day/Twilight	3	360	20,000 ± 25%
Night	3	360	2,000 ± 25%
	High-intensity flashing white lights, towers and stacks 1/		
Day	3 to 7	360	270,000 ± 25%
Twilight	3 to 7	360	20,000 ± 25%
Night	3 to 7	360	2,000 ± 25%
	High-intensity flashing white lights, transmission line supports 1/		
Day	3 to 7	180 or 360	140,000 ± 25%
Twilight	3 to 7	180 or 360	20,000 ± 25%
Night	3 to 7	180 or 360	2,000 ± 25%
	Vehicle obstruction beacons		
Full	10	360	40 min. 400 max 2/.

1/ Multiple lights may be used to obtain horizontal coverage

2/ The minimum and maximum are for the horizontal plane, but the peak may be greater at higher vertical angles.

6.8. Control Requirements:

6.8.1. Obstruction lights intended for day marking shall remain on at all times and shall have automatically selected reduced intensity levels for night operations. Other obstruction's lights shall be on when the northern sky illumination falls on a vertical surface to a level of not less than 350 lux (35 foot candles), or during daytime, when visibility is restricted. The lights may be turned off when the northern sky illuminance rises to a level of (580 lux) 58 foot candles or more.

6.8.1.1. Dual Lighting. This system consists of red lights for nighttime, and high or medium intensity flashing white lights for daytime and twilight. When the dual system incorporates medium flashing intensity lights on structures 150 meters (500 feet) or less, or high intensity flashing white lights on structures of any height, other methods of marking may be omitted.

6.8.2. If practicable, obstruction lights should be controlled from the airfield lighting control panel. Otherwise use automatic controls and provide a locked auxiliary manual control at ground level on the exterior of the object to be lighted.

6.9. Monitoring Requirements. Obstruction lights should be visually observed at least once each 24 hours. If the lighting can not be readily observed, provide a remote monitoring system to indicate the malfunction of all the top lights and any flashing or rotating beacons regardless of their position.

6.10. Availability of Advisory Circulars. Obtain copies of FAA Advisory Circular AC 70/7460-1 from:
US Department of Transportation
General Services Section
M-443.2
Washington, DC 20590
To be added to their mailing list write to:
US Department of Transportation
Distribution Requirements Section
M-483.1
Washington, DC 20590

6.11. Compliance with International Standards:
6.11.1. NATO. These standards meet the requirements of STANAG 3346, Marking and Lighting of Airfield Obstructions, except for the use of high intensity white lights.
6.11.2. ASCC. These standards meet the requirements of AIR STD 65/3, Lighting and Marking of Airfield Obstructions.

Chapter 7

STANDARDS FOR LIGHTING HELIPADS

7.1. General Description. Helipad lighting defines the helicopter landing pad during operations at night and during periods of poor visibility. It is used for single helicopter landing pads when authorized as an operational requirement. For Heliport and Helicopter landing lanes lighting system criteria, refer to Chapter 8. All lighted helipads shall have perimeter lighting; however, local conditions and usage may require the addition of:

7.1.1. Landing direction lights, where there is a preferred landing direction. (See paragraph 7.2.2).

7.1.2. Approach direction lights, where approach guidance is needed to restrict the path of approach to the helipad. (See paragraph 7.3.2).

7.1.3. Helipad IMC approach lights, where additional approach guidance is required in IMC.

7.1.4. Pad floodlighting, to aid in landing safely in bad weather and to assist in ground operations.

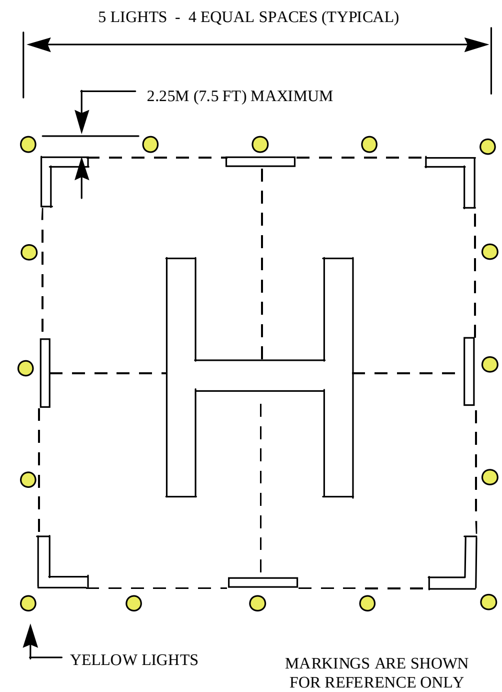
7.1.5. A heliport beacon, where a helipad is not part of an airfield and there is an operational requirement to provide assistance in locating the helipad.

7.2. Helipad Perimeter Lights:

7.2.1. Purpose. Perimeter lights provide visual cues to pilots for identifying the safe operational limits of the helipad during takeoff, landing or hover operations.

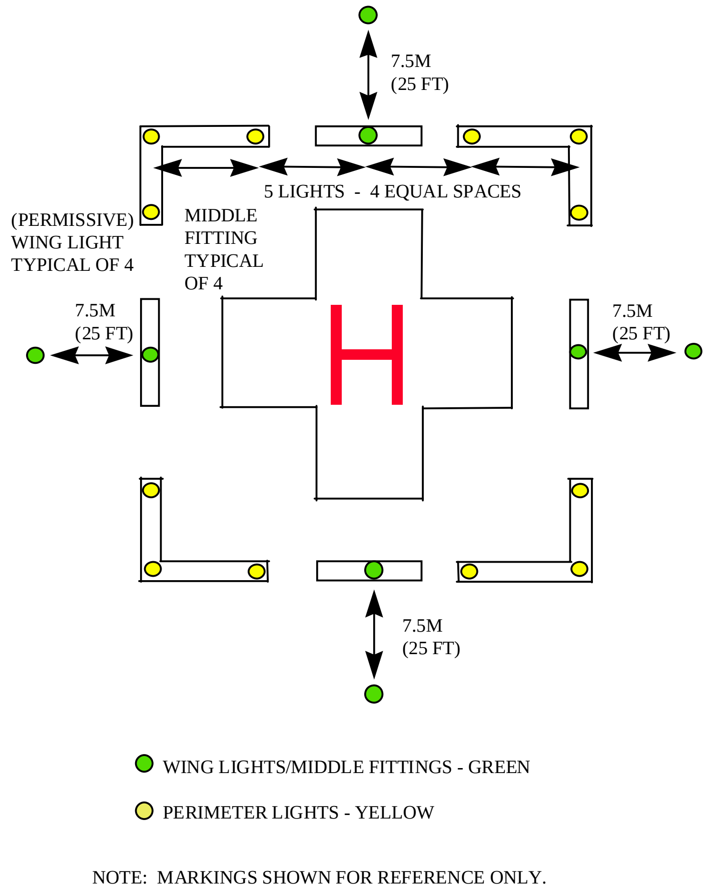
7.2.2. Standard Perimeter Light Configuration. Place aviation yellow, omni-directional lights at each corner of the helipad, with three more lights spaced equally along each side between the corner lights. Lights on opposite sides of the helipad shall be opposite each other. They shall be equidistant and parallel to the extended centerlines of the helipad. They are usually located on the perimeter of the helipad, but may be placed not more than 2.25 meters (7.5 feet) away from the edge of the pad. Use elevated light fixtures, except in pavement fixtures shall be used where taxiing of wheeled helicopters, skid mounted helicopters or other vehicular traffic is required. Elevated light fixtures should preferably be 0.35 meters (14 inches) maximum. (See figure 7.1).

Figure 7.1. Helipad Perimeter Lights, Standard Configuration.



7.2.3. Hospital Pad Perimeter Light Configuration. The lighting of hospital helipad is the same as the standard helipad perimeter lights in paragraph 7.2.2, except there are additional wing lights located on the geometric centerlines of the helipad at a distance of 7.5 meters (25 feet), as shown in figure 7.2, outboard of the existing perimeter light fittings.

Figure 7.2. Helipad Perimeter Light, Hospital Configuration.

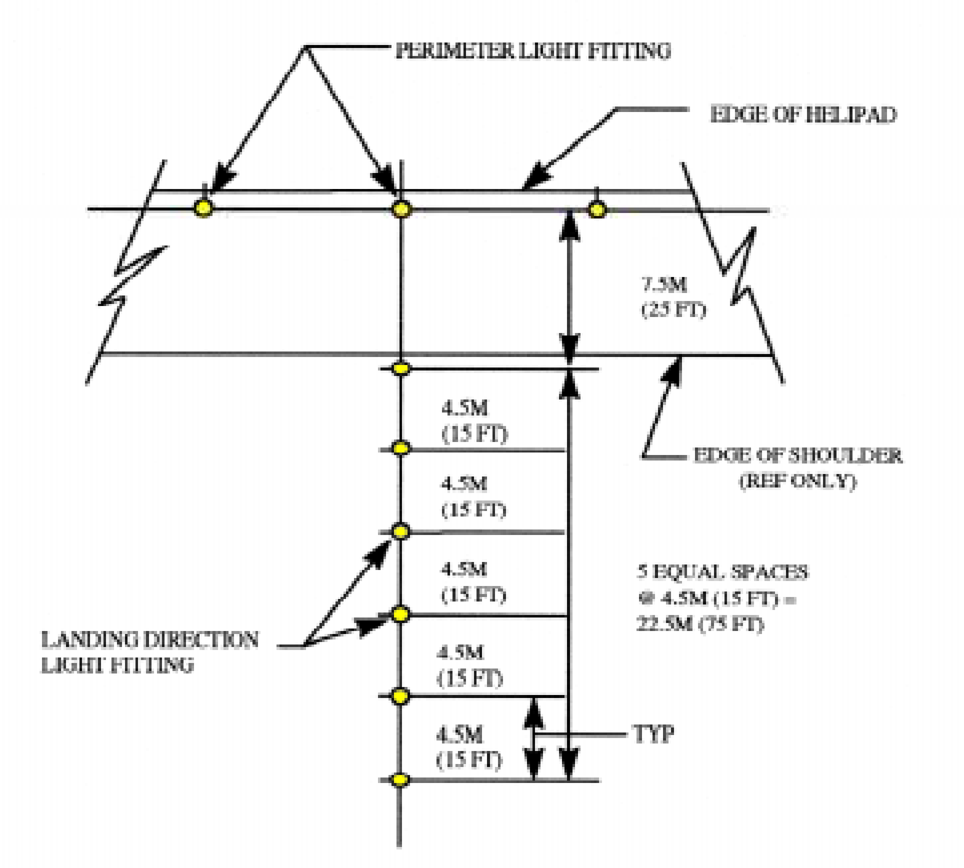


7.3. Helipad VFR Landing Direction and Approach Lights. These lights are installed whenever it has been determined that the need to indicate a specific landing direction, in the procedure for touchdown or hover at the helipad, is a requirement.

7.3.1. Configuration of Landing Direction Lights. Provide aviation yellow omni-directional lights in a straight line along one or more of the centerlines of the helipad, extended, and perpendicular to the perimeter lights. They shall consist of six lights spaced 4.5 meters (15 feet) apart and starting 7.5 meters (25 feet) from the middle perimeter light. Locate the lights in a horizontal plane. (If a deviation is necessary, a tolerance of plus 2 percent or minus 1 percent in the longitudinal slope is permitted). Use elevated fixtures on frangible supports, except in pavement fixtures shall be used when taxiing is a requirement. (See figure 7.3).

7.3.2. Purpose of Approach Direction Lights. These lights are installed whenever it has been determined that approach guidance is required in order to restrict the path of approach to the helipad or additional guidance is needed by the pilots.

Figure 7.3. VFR Helipad Landing Direction Lights.



7.3.2.1. Configuration of Approach Direction Lights. Provide aviation white, omni-directional lights in two parallel rows extending out from the landing direction lights. Each row shall consist of five lights spaced 15 meters (50 feet) apart, starting 37.5 meters (125 feet) from the perimeter lights and offset 1.5 meters (5 feet) either side of the extended centerline of the landing direction lights. The slope of the approach direction lights shall be the same as that used for the landing direction lights. (See figure 7.4).

7.3.3. Helipad IMC Approach Lights.

7.3.3.1. Purpose. These lights are installed whenever it has been determined that additional approach guidance is considered necessary for instrument meterological conditions, with a decision height of 60 meters (200 feet) and an RVR of 720 meters (2,400 feet).

7.3.3.2. Configuration of IMC Approach Lights. The approach lighting system will be symmetrical about, and extend for the entire length of, the centerline of the helipad direction lights. This additional light system starts at the position of the approach direction lights, shown in figure 7.3, at 37.5 meters (125 feet) from the helipad and extending out to 1,025 feet. See figure 7.5.

Figure 7.4. Helipad VFR Approach Direction Lights.

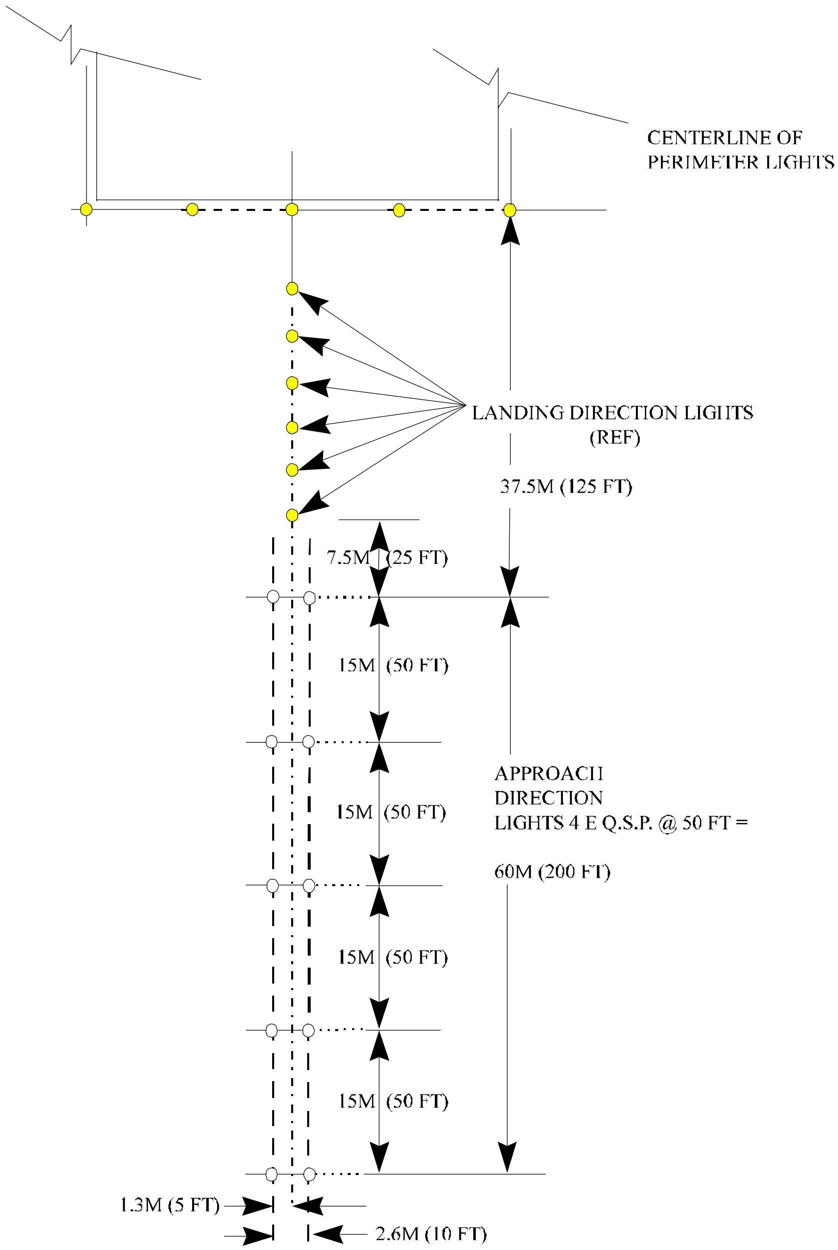
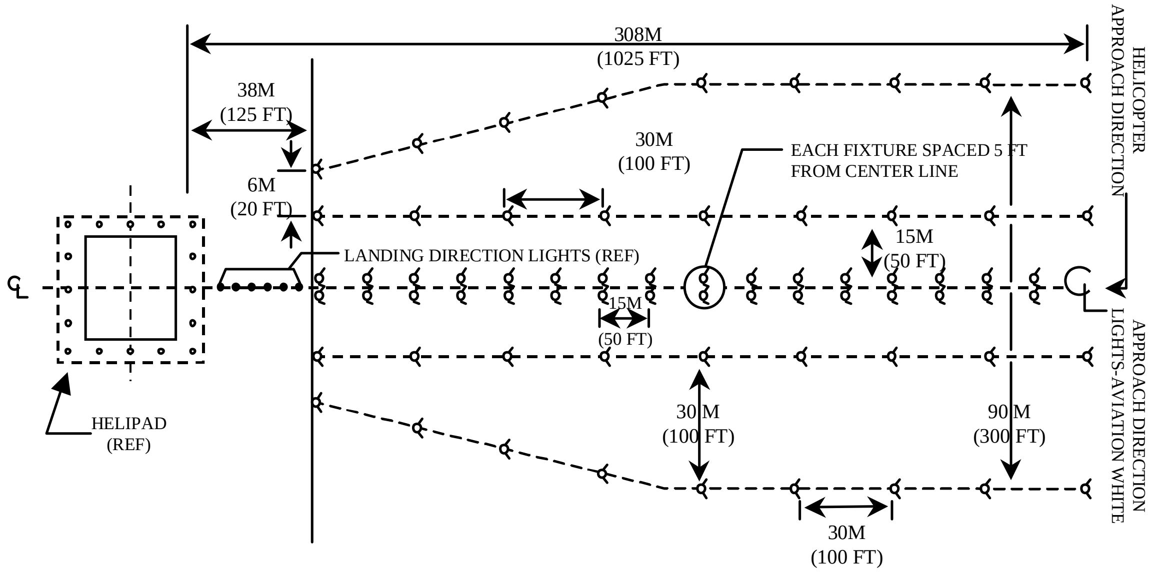


Figure 7.5. IFR Approach Lights.



NOTES:
(1) ○ Elevated or semi-flush omni-directional light fixture with luminous features.
(2) ● Normally elevated omni-directional light fixture with luminous features.
(3) Normally elevated uni-directional light fixtures.
(4) Elevated light fittings to be frangible with break-off point at top edge of base mounted plate.
(5) Light fixtures shall be mounted on a horizontal plane and shall not be greater than 18 inches above grade of the helipad. Where deviation of the horizontal plane is necessary, tolerance is to be +2% or -1% in the longitudinal slope. Where a slope is established for the landing direction lights, the same slope shall be continued for the approach direction lights.
(6) Glide slope and setting angles:

	glide slope angle	setting angle
	3 degrees	6 degrees
	8 degrees	11 degrees
	9 degrees	15 degrees

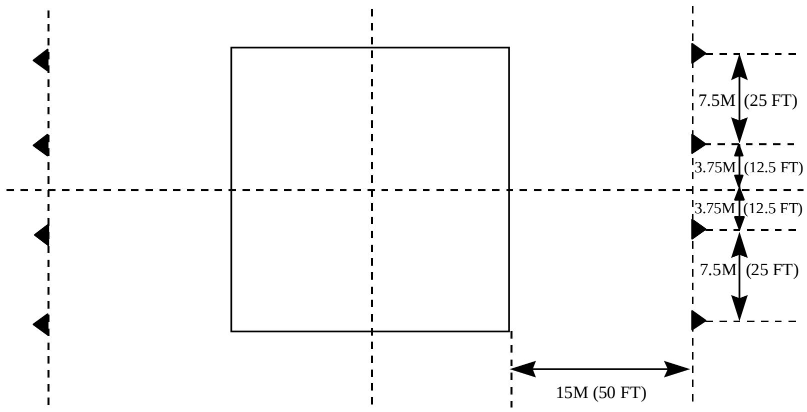
(7) If multiple glide slope angles are used, the mean value of 11 degree setting angle shall be used. Three or five progressive stages of brilliance are required for approach direction lights.
Intensities: A. Horizontal plane 20,000 CDS beam spread ± 7.5 °.
B. Horizontal plane 5,000 CDS beam spread ± 12.5 °.

7.4. Helipad Floodlights:

7.4.1. Purpose. Helipad floodlights may be used to illuminate the helipad surface at night to provide visual cues to the pilot for determining his height above the surface during the touchdown phase of his approach. The floodlights shall provide vertical illumination on the helipad surface that averages not less than two footcandles with the ratio of the average value to the darkest area not greater than 4:1. An average illumination of five footcandles is preferred. To prevent interference with or damage to an aircraft, the helipad floodlights shall be as close to grade as practical and have frangible couplings. The floodlights shall provide a uniform illumination of the helipad surface. When installed, the fixtures shall not permit any direct light to be visible above the horizontal. The fixture shall emit a narrow fan-shaped illuminating beam for which the axis of the beam shall be adjustable in elevation between 1 degree up and 5 degrees from horizontal. Another purpose is for ground operations on a helipad where access to a lighted apron is not available for loading or unloading of equipment or personnel. A typical application would be a helipad located near a hospital or headquarters building.

7.4.2. Configuration of Helipad Floodlights. Locate these lights 15 meters (50 feet) beyond the edges of the helipad on two opposite sides, parallel to the normal approach to the helipad. Mount the floodlights not over 1.2 meters (4 feet) above the grade of the helipad with a small obstruction light at each floodlight visible from any direction. The number of floodlights installed depends on the size of the helipad and the light output of the fixtures used. (See figure 7.6).

Figure 7.6. Helipad Floodlight Configuration.



7.5. Helipad Approach Slope Indicator:

7.5.1. Purpose. A visual glide slope indicator should be provided for a helipad when obstacle clearance, noise abatement or traffic control procedures require a particular approach slope angle be flown, or when the environment of a helipad provides few visual cues, or the characteristics of a particular helicopter requires a stabilized approach path. The recommended system is Chase Helicopter Approach Path Indicator (CHAPI).

7.5.2. Configuration. The CHAPI system consists of 2 transition light units projecting red/green/white lights. They are located forward of the helipad on the extended centerline at a distance determined in order to project an on glide path angle (usually 6 degrees) at the helipad hover point prior to touchdown. The units are positioned at approximately 6.6 meters (20 feet) apart lateral (horizontal). The CHAPI system shall be constructed and mounted as low as possible and be sufficiently light weight and frangible so as not to constitute a hazard to helicopter operations.

7.6. Helipad Identification Beacon:

7.6.1. Purpose. A helipad beacon should be provided when long range guidance is considered necessary and not provided by other means, or helipad identification is difficult due to surrounding lights.

7.6.2. Configuration. The beacon shall contain a colored sequence of lights, double peak white flash, and a single peak green and yellow. The flash shall be 10 to 15 sequences of flashes per minute. The time between each color should be 1/3rd of the total sequence time. The beacon should not be installed within 1.6 kilometer (1 mile) of any existing airport beacon or other helipad area.

7.6.3. Construction. The beacon should be visible for a distance of 1.6 kilometer (1 mile) in 1.6 kilometer (1 mile) VMC visibility daylight, and 4.8 kilometer (3 miles) in 4.8 kilometer (3 miles) VMC at night, both from an altitude of 915 meters (3,000 feet) above ground level. The beacon should be mounted a minimum of 15 meters (50 feet) above the helipad surface. Where a control tower or area is utilized the beacon should be no closer than 122 meters (400 feet), nor further than 1,067 meters (3,500 feet), from that area, and not located between the control tower and the helipad.

7.6.4. Luminous Features. The main beam of the light should be aimed a minimum of 5 degrees above the horizontal and should not produce light below the horizontal in excess of 1,000 candelas. Light shields may be used in order to reduce the intensity below the horizontal.

7.7. Helipad Wind Direction Indicators:

7.7.1. Purpose. When utilized they will enhance operational capabilities, increase safety and reduce pilot workload during approach, hover and takeoff operations.

7.7.2. Configuration. A helipad should be equipped with at least one wind direction indicator located in a position in order to indicate the wind conditions over the final approach and take-off area. The wind indicator shall be free from the effects of air flow disturbances caused by nearby objects or rotor wash. It shall be visible from a helicopter in flight, in a hover, or on the movement area. Where a helipad may be subject to a disturbed air flow, additional indicators located close to the area may be necessary to indicate surface winds.
7.7.3. Construction. A wind direction indicator shall be constructed in order to give a clear indication of the wind direction and a general indication of the wind speed. An indicator should be a truncated cone made of light weight fabric. The approximate minimum dimensions are 2.4 meters (8 feet) long, 0.45 meters (18 inches) diameter (large end), and 0.3 meters (1 foot) diameter (small end). The color selected shall make it clearly visible and understandable from a height of at least 200 meters (650 feet) above the helipad. When practical the preferred colors should be white or orange. Where it is necessary to provide adequate conspicuity against varied backgrounds, combined colors are permitted such as orange and white, red and white, or black and white.
7.7.4. Illumination. A wind direction indicator intended for use at night shall be illuminated.

7.8. Photometric Requirements:
7.8.1. Perimeter and Landing Direction Lights. These lights shall emit omni-directional aviation yellow light with intensities as follows:

2 to 10 degrees vertical	37 cd min.	67 cd average
10 to 15 degrees vertical	20 cd min.	

7.8.1.1. A 25 percent reduction in light output is permitted at structural ribs on in pavement lights.
7.8.2. Approach Direction Lights. These lights shall emit omni-directional aviation white light with intensities as follows:

2 to 10 degrees vertical	5 cd min.	125 cd average
10 to 15 degrees vertical	40 cd min.	

7.8.2.1. A 25 percent reduction in light output is permitted at structural ribs of in pavement lights.
7.8.3. Helipad Floodlights. These fixtures shall direct the entire output of the fixture below the horizontal. The average luminance shall be 20 lux (2 foot candles) with a uniformity ratio (average to minimum) of not more than 4 to 1.
7.8.4. Helipad Beacons. These lights are rotating or flashing lights. They shall appear to an observer at any azimuth as a series of flashing lights coded white-green-yellow. The flash duration shall be 75 to 300 milliseconds. The effective intensities of white light for vertical angles above the horizontal shall be:

1 to 2 degrees	12,500 cd
2 to 8 degrees	25,000 cd
8 to 10 degrees	12,500 cd

The minimum intensities of the green flashes shall be 15 percent of those given for the white light, and the minimum effective intensities of the yellow flashes shall be 40 percent of that given for the white light.
7.8.5. The CHAPI light units are similar to a PAPI system (see Chapter 4, paragraph 4.7.1), with the addition of a 2.0 degree wide green sector command path. The vertical color sectors for the CHAPI system are:

above course	7.5 degrees or more	W	W

slightly high	6.5 to 7.5 degrees	W	G
on course	6.0 degrees	G	G
slightly low	4.5 to 5.5 degrees	G	R
below course	4.5 degrees or less	R	R

7.9. Power Requirements. Provide a main and an alternate power system with the capability to automatically transfer within 15 seconds from the system in use if a system fails. Typical lighting control diagrams for helipad lighting systems are shown in figures 7.7 for systems without a control tower, and in figure 7.8 with systems with a control tower.

Figure 7.7. Control Diagram Without Tower.

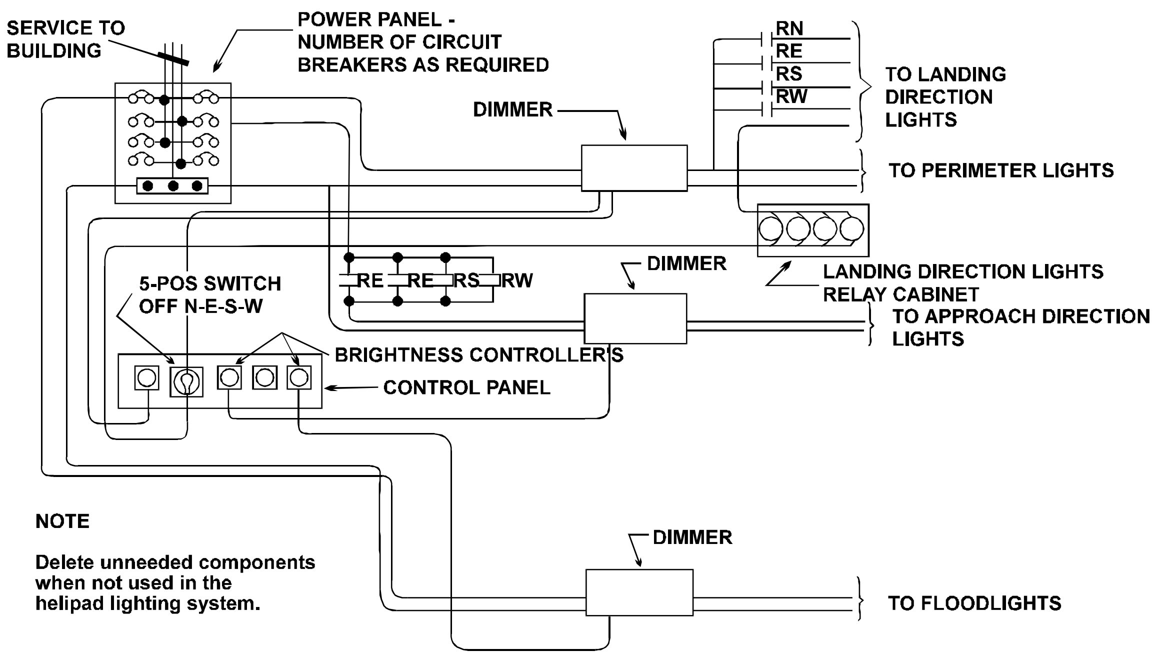
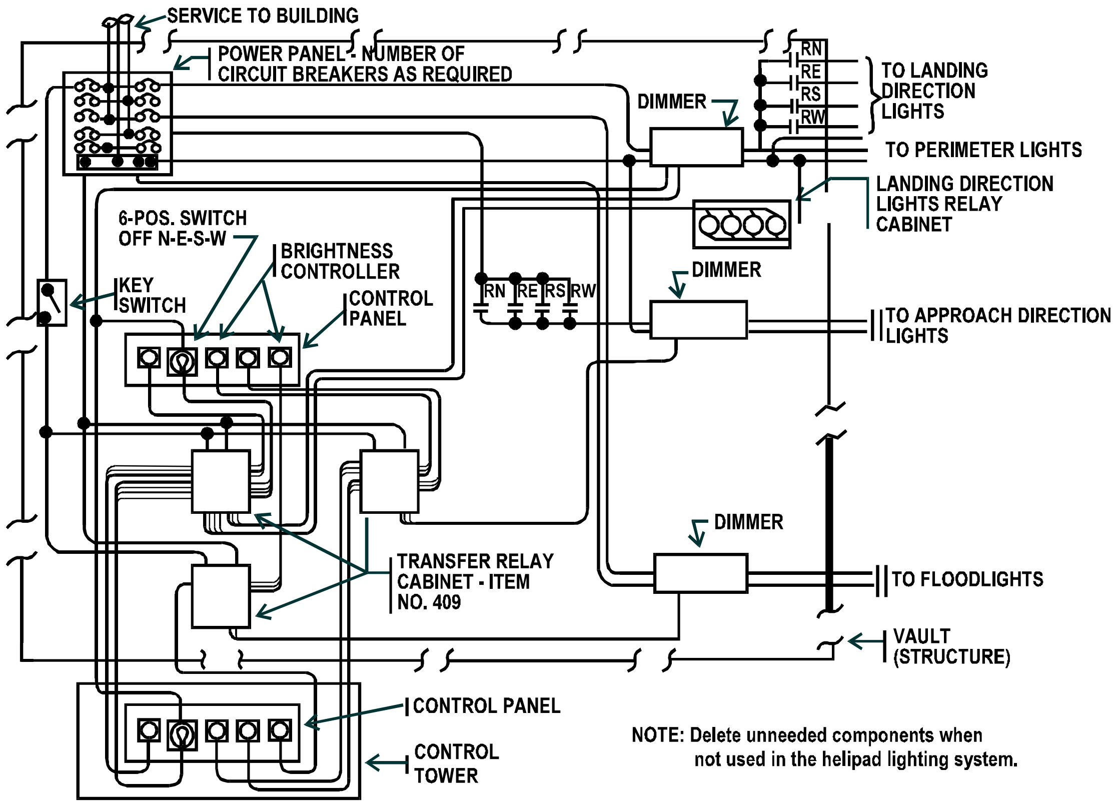


Figure 7.8. Control Diagram With Tower.



7.10. Control Requirements:

7.10.1. Perimeter Lights. Provide on and off control and a three step intensity control.

7.10.2. Landing Direction Lights. Provide on and off control and a three step intensity control. The controls shall be interconnected with the perimeter light controls in order to prevent operation without the perimeter lights being activated; however, they shall have the capability of being independently turned off. The intensity of the perimeter lights may be used to permit connection to the same current regulator.

7.10.3. Approach Direction Lights. Provide on and off control and a three step intensity control. The controls shall be interconnected to the landing direction light circuit in order to prevent their operation unless the landing direction lights are activated; however, they shall also be capable of being turned off independently. The intensity controls may be connected to the same regulator as the landing direction lights.

7.10.4. Helipad Floodlights. Helipad floodlights require on and off control and intensity control from blackout to full intensity.

7.10.5. Helipad Beacons. Provide on and off control only.

7.10.6. CHAPI. Provide on and off control and a minimum of three step intensity control, similar to the PAPI system.

7.11. Monitoring Requirements. There are no requirements for monitoring helipad lighting systems.

7.12. Compliance with International Standards:

7.12.1. ASCC. These standards meet the requirements of AIR STD 65/34, for helipad lighting.

7.12.2. NATO. These standards meet the requirements of STANAG 3619, for helipad lighting.

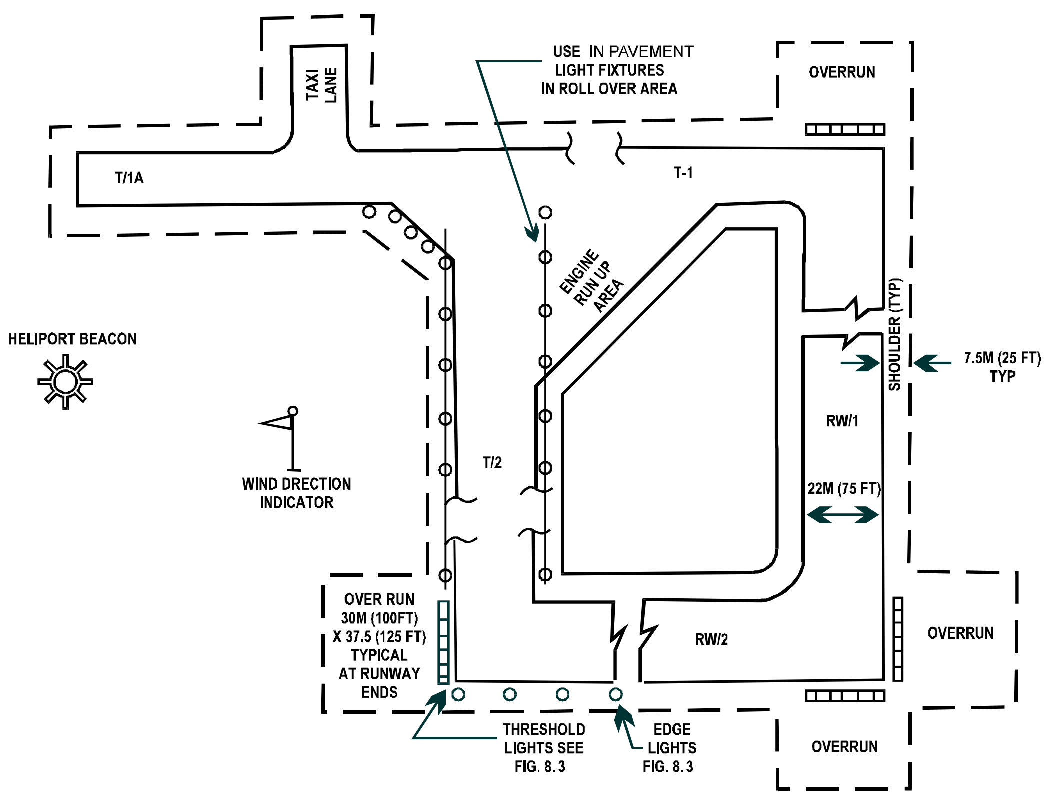
7.13. Equipment. See Chapter 12, paragraph 12.14, for appropriate Helipad lighting equipment.

Chapter 8

STANDARDS FOR LIGHTING HELIPORTS

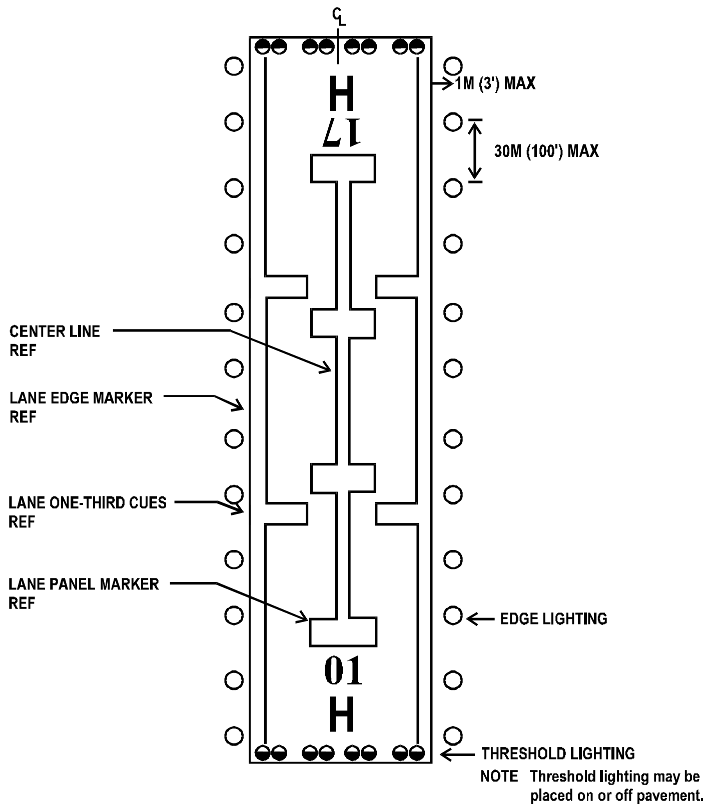
8.1. General Description:
8.1.1. A helicopter runway is a prepared surface used for the approach and departure of rotary wing aircraft. It is not intended for use of fixed wing aircraft.
8.1.1.1. Heliport Runway. The design criteria set forth herein are intended to guide in the designing and installing a permanent Army heliport lighting system utilizing elevated and in pavement lights. Figure 8.1 shows an illustrated example of a typical heliport having two 22 meter (75 foot) wide by 480 meter (1600 foot) long intersecting runways with 12 meters (40 foot) wide connecting taxiways and 7.5 meters (25 foot) wide adjacent surface treated shoulders. Changes in the layout or design may be necessary in order to fit the requirements of a particular heliport runway installation, including a basic one runway configuration.

Figure 8.1. Layout Heliport Lighting.



8.1.2. Rotary wing landing lanes permit efficient simultaneous operations by a number of helicopters (in most cases, up to four at one time) while additional helicopters are in a designated traffic pattern.
8.1.2.1. Rotary Wing Landing Lanes (formerly Stagefields). Figure 8.2 and the associated design criteria contained herein are intended to guide in the designing and installing a permanent Army rotary wing landing lane which is normally 480 meters (1600 feet) long and 22 meters (75 feet) wide, utilizing elevated or in pavement light fixtures.

Figure 8.2. Rotary Wing Landing Lane.



8.2. Heliport Lights:

8.2.1. Runway Edge Lights (White). The line of edge lights, aviation white, shall be located on each side of a heliport runway, they will not be less than 1.5 meters (5 feet), nor more than 3 meters (10 feet) from the paved edge of the runway. The lights will be of the elevated type. The lights will be uniformly spaced at 30 meters (100 feet). Where intersecting runways or intersections between runways and/or taxiways occur, spacing of the edge lights will be uniform between paving intersection points of tangency (PT's) with each section calculated separately.

8.2.2 Runway Edge Lights (Blue). When a runway is also used as a taxiway, such as two runways at 90 degree intersections, where one of the runways lead to a taxiway opposite to the approach end, aviation blue taxiway lights will be installed in addition to the white lights. The line of blue lights will be spaced at 30 meters (100 foot) maximum intervals, between the white lights. These blue lights shall be connected to the appropriate intersecting taxiway circuit. Where only one runway is constructed, blue lights will not be installed. All lights both white and blue located in runway or taxiway intersections where subjected to rollover traffic will be the in pavement type.

8.2.3. Runway Threshold Lights. The line of in pavement threshold lights shall be bi-directional, 180 degrees aviation green and 180 degrees aviation red, located not less than 1.5 meters (5 feet) or more than 4.5 meters (15 feet) from the runway ends, with the lights spaced approximately 5 meters (17 feet) on centers. The outer most light of each group will be located in line with the corresponding row of runway edge lights. Each group of threshold lights will contain a minimum of six lights. When the line of runway edge lights are located at the maximum distance of 3 meters (10 feet) from the pavement edge of the runway, an additional in pavement light will be installed in each group for a total of 7 lights in each group. The threshold lights should be controlled with the runway edge light circuit.

8.2.4. Taxiway Lights and Signs. Taxiway lighting and associated taxiway guidance signs will be in accordance with the criteria stated in Chapter 5.

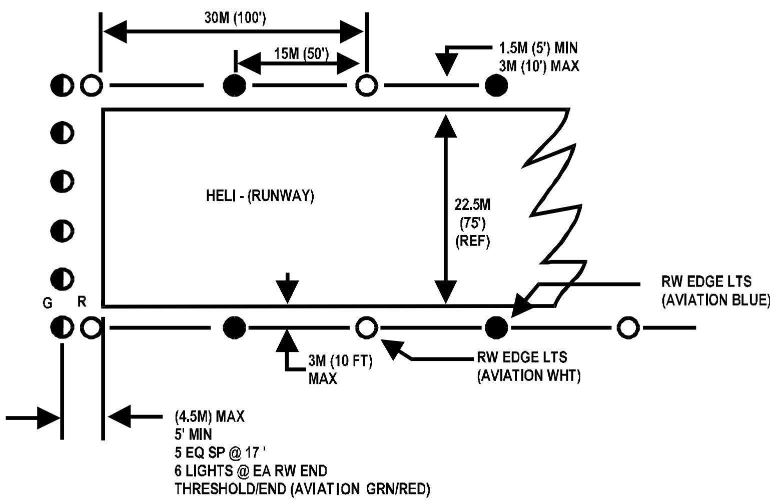
8.2.5. Approach Lights. Approach light systems, when considered necessary should be installed in accordance with the criteria cited in Chapter 7 for VFR or IFR conditions as appropriate.

8.3. Rotary Wing Landing Lanes:

8.3.1. Edge Lights. The edge lights on landing lanes shall be aviation white in color, located on a line 1 meter (3 feet) maximum from the edge of the full strength pavement that is designated for lane use as illustrated in figure 8.3. The longitudinal spacing shall be uniform and not greater than 30 meters (100 feet), on each side of the landing lane. When two or more landing lanes are lined up parallel, or in close proximity to each other, the lane edge lights will be configured so they will not line up and create a false runway orientation configuration when helicopters are approaching from perpendicular or oblique angles to the landing lane centerlines. The height of the light fixture will not exceed 0.3 meters (14 inches) above grade, except when snow accumulations of 0.3 meters (12 inches) will be frequent, the edge light height may be increased to 0.6 meters (24 inches) above grade. The light fixtures will be mounted on frangible posts of not more than 2 inches in diameter. Each landing lane edge light system will be equipped with a 5 step constant current regulator which permits control from blackout to full intensity. For additional information see Chapter 12, or refer to FAA AC 150/5340-24.

8.3.2. Threshold/End Lights. Combination threshold and lane end light fixtures, shall be located on a line perpendicular to the extended centerline of the landing lanes. The line of lights shall not be less than 0.6 meters (2 feet) nor more than 3 meters (10 feet) outboard from the designated threshold of the landing lane. The lights should consist of four groups of two lights symmetrically located perpendicular to the extended centerline of the landing lanes, see figure 8.3.

Figure 8.3. Heliport Threshold and Edge Light Details.



8.4. Refueling Area Lights. A hazardous location exists within 15 meters (50 feet) of an aircraft fuel inlet, i.e. dispensing nozzle or fuel system vent and within 19 meters (63 feet) of an aircraft direct fuel outlet/hose reel pit. Refueling areas are Class 1, Division 1, Group D hazardous locations as defined in National Fire Protection Association NFPA 70 National Electrical Code. The light fixture assemblies and associated wiring shall be suitable for installation in the hazardous location. Refer to FAA AC 150/5345-39 for the use of retro-reflective markers.

8.5. Lighting Equipment:

8.5.1. Elevated Runway and Landing Lane Edge Lights. Elevated runway edge lights will be omnidirectional, medium intensity. The lamp for this light will be approximately 30 watts, 6.6 amperes, as recommended by the manufacturer. FAA type L-861 is recommended (see figure 12.12).
8.5.2. In pavement Runway Lights. In pavement runway lights will be medium intensity. FAA type L-852 E is recommended, see figure 12.13. Where rollover is anticipated on a runway or taxiway, in pavement light fixtures of the appropriate color shall be used.
8.5.3. Threshold Lights. In pavement threshold lights will be similar to the lights in paragraph 8.5.2., except that a 180 degree aviation green, 180 degree aviation red filter, shall be supplied with the light fixture.
8.5.4. Runway Blue Lights. Elevated and in pavement lights will be aviation blue, and be of the types cited in the above paragraphs.
8.5.5. Refueling Area Lights. Fixture assembly must meet the requirements Underwriters Laboratories (UL) test and approval requirements as stated in UL 844 for class 1, division 1, group D hazardous locations as defined in NFPA 70. The fixture assembly will include a light fixture, frangible coupling, power disconnect switch that will kill power if the frangible mount is broken, and a junction box. As an alternative, the light fixture assemblies and associated wiring shall be intrinsically safe and meet Underwriters Laboratories (UL) test and approval requirements as stated in UL 913 for class 1, division 1, group D hazardous locations as defined in NFPA 70.
8.5.6. Runway and Taxiway Signs. When operational requirements consider it necessary to install informational of mandatory guidance signs see Chapter 5 for guidance. Runway and taxiway signs are designated in two groups, mandatory signs are white letters on a red background, and information signs are black letters on a yellow background.

8.6. Power Requirements. Runway lighting systems will be supplied through interleaved series circuits served by constant current regulators. The regulators are available in various load capacities and output current values, and have brightness controls so that the light output can be adjusted to suit the visibility conditions.
8.6.1. Circuit Criteria. The number and type of regulators required will be determined by the circuit length. Power losses from cable lengths to and from the lighting vault to the lights and the isolation transformer loss shall be addressed when designing the lighting system.
8.6.2. Cable connectors, Plug and Receptacles. See Chapter 12.
8.6.3. Cables used for series circuit. Will be No.8 or No. 6 AWG 1/C stranded, 5,000 volt, cross-linked polyethylene. See paragraph 12.8.9. and FAA AC 150/5345-7. Use No. 6 AWG cable with 20 ampere circuits and long circuit runs.
8.6.4. Isolation transformers. See paragraph 12.8.11 for information.

8.7. Control Requirements. The heliport lighting control system is an integral part of the control system for all heliport lighting facilities. The function of this portion of the control system is to energize and de-energize the selected runway lighting systems, and to control the brightness of the lights. All lights will be controlled from the control tower and from the lighting equipment vault. The circuits will be provided and connected as indicated in figure 8.2, with the runway/taxiway combination control panels and associated equipment connected to permit separate control of each heliport lighting system, independent of each other, and permit simultaneous control of the taxiway circuits in combination. Coordinate the need to interlock the lighting on intersecting runways so that both runway lighting systems cannot be energized simultaneously. Taxiway circuit T-1A will be connected with separate individual control, in order to permit flexibility in the operation of the runway and taxiway lights either singly, in combination, or simultaneously, as required for the heliport operations by the control tower

operator. The layout will also allow for future changes, and expansion in the methods of operation with a minimum of expense and interruption of service.
8.7.1. Edge lights and threshold lights shall be provided with 3 intensities as follows:

Intensity Step	Percent of Full Intensity
1	10%
2	20%
3	100%

If required by the operations community, for compatibility with night vision goggles, the edge lights and threshold lights may be provided with 5 intensities as follows:

Intensity Step	Percent of Full Intensity
1	0.16%
2	0.8%
3	4.0%
4	20%
5	100%

8.7.2. Basic Operations. The initial sequence of operations of the heliport lighting circuits anticipated is such that when helicopters are utilizing the night landing facilities of the heliport: (1) the blue taxiway lights, (circuits T-1 and T-2) will be turned on, but (2) only the white edge lights, and green/red threshold lights, (circuits R-1 or R-2) of the runway in use will be turned on, use figure 8.4 as a reference.

Example: White edge lights, R-1, ON
Threshold lights, R-1, ON
Blue edge lights, R-2, ON
Blue edge lights, T-2, ON
Blue edge lights, T-1A, ON
All other taxiway/runway lights, OFF

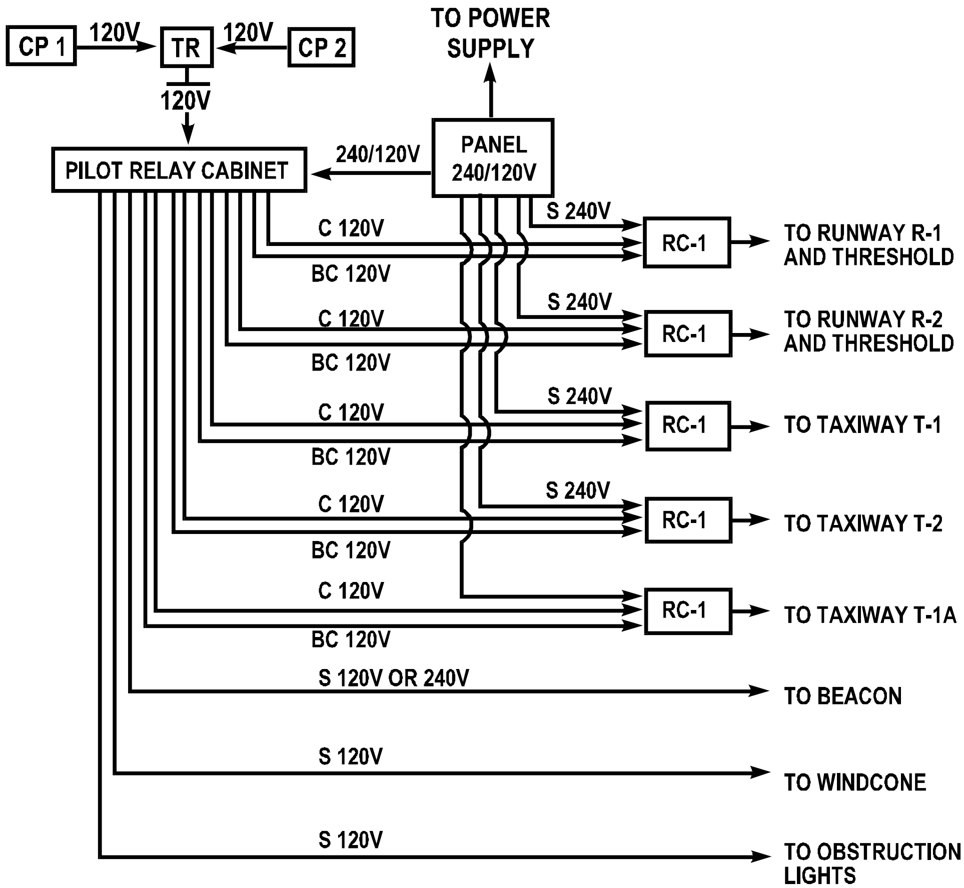
The above example will allow a helicopter to land on R-1, taxi on R-2, taxi on T-2, and proceed to a designated area via T-1A.

8.8. Monitoring Requirements. There are no requirements for monitoring the lighting systems on heliports or rotary landing lanes.

8.9. Compliance with International Standards:
8.9.1. ASCC. There are no air standards for heliports or landing lanes.
8.9.2. NATO. There are no standards for heliports or landing lanes, however STANAG 3619 makes reference to the US Army criteria for IFR approach lighting.

8.10. Equipment. See Chapter 12, for lighting equipment.

Figure 8.4. Block Diagram Typical System.



LEGEND

CP-1 - Control Point Primary (Control Tower)
CP-2 - Control Point Alternate (Vault)
RC-1 - Regulator
TR - Transfer Relay
BC - Brightness Control
C - Control
S - Supply

NOTE: Electric power source, main service switch, emergency generator and transfer switch and main distribution panel not shown. Installation of theses items will be designed to meet local conditions.

Chapter 9

MISCELLANEOUS LIGHTED VISUAL AIDS

9.1. Airport Beacons:

9.1.1. Purpose. Airport beacons are high-intensity flashing lights which provide a visual signal to pilots to assist in locating and identifying the airfield or a hazardous obstruction at night or in restricted visibility conditions. These beacons may be rotating or fixed, but shall provide the signal through 360 degrees of azimuth. These requirements are to be used for new installations of airport beacons. Existing installations may continue to be used and maintained.

9.1.2. Beacon Types:

9.1.2.1. Airfield Rotating Beacon. Each lighted airfield, except where one rotating beacon serves more than one airfield in close proximity, shall use a high-intensity military type beacon. This beacon shall have a double-peaked white beam to denote a military airfield and a single-peaked green beam to indicate that the airfield has lighted facilities for operations at night or in restricted visibility. The two beams shall be directed 180 degrees apart. The signal from the beacon shall be visible through 360 degrees of azimuth by rotating at six revolutions per minute (RPM). The airfield rotating beacon shall be operated during twilight and night hours and during daytime when Instrument Flight Rules (IFR) are in effect. Alternating white and green flashes identify a lighted civil airport, and white flashes identify an unlighted civil airport.

9.1.2.2. Identification or Code Beacon. The identification beacon is used only at airfields where the airfield rotating beacon is located more than 5,000 feet from the nearest runway or where the airfield rotating beacon serves more than one airfield. The identification beacon is a non-rotating flashing omni-directional light visible through 360 degrees. This beacon flashes a green coded signal at approximately 40 flashes per minute. The signal is an assigned code of characters to identify the particular airfield. The identification beacon shall be operated whenever the associated airfield rotating beacon is operated.

9.1.3. Location Requirements. The standard location for the airfield rotating beacon or the identification beacon shall be:

- Visible through 360 degrees of azimuth if possible.
- Not less than 1,000 feet from the centerline or centerline extended of the nearest runway.
- Not in the line of sight from the control tower to the approach zone of any runway or to within 22 meters (75 feet) vertically over any runway.
- Located 225 meters (750 feet) or more from the control tower.
- Not more than 450 meters (5,000 feet) from the nearest point of usable landing area, except if surrounding terrain will restrict visibility of the beacon through an appreciable angle in some directions or the beacon will serve more than one airfield. If terrain restricts viewing the beacon, the distance of the beacon from the nearest runway may be increased to not more than two miles.
- The base of the beacon shall be not less than 6 meters (20 feet) higher than the elevation of the floor of the control tower cab.
- If the airfield rotating beacon is located more than 1,500 meters (5,000 feet) from the nearest point of usable landing area, an identification beacon shall be installed and not more than 1,500 meters (5,000 feet) from the nearest point of usable landing area.

9.1.4. Photometric Requirements. The photometric requirements for the airfield rotating beacon and the identification beacon shall be:

9.1.4.1. Colors. The color of the emitted light shall be standard aviation colors in accordance with the latest FAA criteria.

9.1.4.2. Airfield rotating beacon. With the lenses and the color filters removed and the beacon stationary and operating at rated voltage, the intensity in white light of each beam shall be not less than 1,200,000 candelas for a distribution not less than one degree horizontally and 4.5 degrees vertically.

9.1.4.3. Identification Beacon. With the beacon operating steadily (not flashing) at rated voltage, the intensity of the green light shall be not less than 1,500 candelas for a distribution through 360 degrees horizontally and 2 degrees vertically. The areas of the beam where the support rods are located may be less than these required intensities.
9.1.5. Aiming. The vertical aiming of the beacons should be properly focused and aimed when manufactured, and leveling should be all that is required for aiming during installation. The axes of the beams vertically should be approximately five degrees above the horizontal for the rotating beacon. For the identification beacon, the center of the beam shall be approximately three degrees above horizontal.
9.1.6. Equipment. The airfield rotating beacon and the identification beacon equipment shall be as shown in Chapter 12, paragraph 12.12. The identification beacon shall be provided with a keyer to flash the assigned identification code.
9.1.7. Power Requirements. The electrical power requirement for the beacons is 120 volts. The source of power may be from the airfield lighting vault or from a local source that is continuously available. If the distance from the power source is long and the line voltage drop is large, transmission of power at a higher voltage and step-down to 120 volts at the site may be desirable. The step-down transformer should be rated at not less than 3 KVA for the rotating beacon or 2 KVA for the identification beacon. Emergency power is not required for the airport beacons, but should be used if it is available.
9.1.8. Control Requirements. The controls for the airport beacons are only those required to energize and switch off the beacon and its drive motor or keyer. Preferably, these beacons should be controlled remotely from the lighting control panel in the control tower or the airfield lighting vault. Control may be furnished by an automatic photoelectric switch or a clock-driven timer.
9.1.9. Monitoring Requirements. There is no requirement for monitoring.
9.1.10. Compliance with International Military Standards. There are no International Military Standards for airport beacons.

9.2. Wind Indicators (Cones):
9.2.1. Purpose. Wind cones are installed near landing surfaces to provide a clear indication of the direction of the surface wind and a general indication of wind speed. Wind cones are lighted for night operation. The base/wing commander sets wind cone requirements with approval from the major command.
9.2.2. Siting Requirements. Locate wind cones not less than 120 meters (400 feet) from the runway centerline and in a location free from the effects of air disturbances caused by nearby objects. If the wind cones are not more than 6 meters (20 feet) above the ground elevation a waiver to use latest designation of documents, Airfield and Heliport Planning Criteria, is not necessary.
9.2.3. Wind Cone Configuration:
9.2.3.1. The wind cones shall be in the form of a truncated cone made of fabric. They shall have a length of not less than 2.4 meters (8 feet) and a diameter at the larger end of not less than 0.45 meters (18 inches). They shall be constructed so it gives a clear indication of the direction of the surface wind and a general indication of the wind speed. Wind cones shall extend fully in a fifteen knot wind.
9.2.3.2. The color(s) shall be selected with consideration given to the background and to make the indicator clearly visible and understandable from a height of at least 300 meters (1,000 feet). Where practicable, use a single color, preferably white or orange. When a combination of two colors is required to provide conspicuity, the preferred colors are orange and white, red and white, or black and white. The colors shall be arranged in 5 alternate bands, the first and last band being the darker.
9.2.4. Lighting Requirements. Illuminate the wind cone with floodlights which are arranged to provide a minimum illumination level of 2 foot candles (20 lux) at any point on the horizontal plane described by a complete rotation of the upper surface of a fully extended cone. The lights shall be shielded to prevent light emission above the horizontal. The wind cone support shall be equipped with an obstruction light.

9.2.5. Power Requirements. Provide a main power source only. If powered from the associated runway edge lights, they will have the provision so the cone floodlight brightness does not vary more than 20 percent with the available light, meeting the requirements of paragraph 9.2.4, at the lowest setting of the runway edge lights.
9.2.6. Control Requirements. On and off control is the only requirement and may be accomplished via the runway edge light circuit if used.
9.2.7. Monitoring Requirements. There are no requirements for monitoring wind cones.
9.2.8. Equipment. The wind indicators shall be as shown in Chapter 12, paragraph 12.12.3.
9.2.9. Compliance with International Standards. There are no ASCC or NATO standards for wind indicators.
9.2.10. See FAA AC 150/5345-27 for additional information.

9.3. Runway and Taxiway Retro-reflective Markers:
9.3.1. Purpose. Reflectors and retro-reflective markers should be used to supplement existing runway and taxiway lighting, or for temporary installations. However, a waiver must be granted by the MAJCOM for their use.
9.3.2. Characteristics. The retro-reflective materials used are designed to reflect light approaching at an oblique angle, back toward the light source.
9.3.3. Equipment. For additional guidance on the types and styles of the markers refer to FAA AC 150/5345-39 and AC 150/5340-24.

Chapter 10

PORTABLE EMERGENCY LIGHTING

10.1. General Requirements. In times of emergency, when standard airfield lighting is not available and aircraft operations must be performed at night, it may be necessary to resort to the use of portable lighting devices to support the operations. The lighting design standards contained in this section may be suitable for use in VFR night operations but do not qualify the airfield for instrument operations of any kind. The standards in this section cover requirements for forward tactical airfields or landing zones. Care should be taken when installing portable lights that they are secured sufficiently to prevent movement as a result of jet blast or other forces. When application of the criteria in this section would result in a light location in an active paved area, the light shall be omitted or relocated as circumstances dictate.

10.2. Runway Lighting:
10.2.1. Runway Edge Lighting. Portable edge light configurations generally follow the standard configuration except that the spacing may be a maximum of 90 meters (300 feet) and the offset may be a maximum of 3 meters (10 feet) from the runway edge. The runway edge lights shall be white.
10.2.2. Runway End and Threshold Lighting. The number of lights required for runway end and threshold lights is reduced to 10. At each end of the runway they shall be placed in two groups of 5 with the outermost lights in each group in line with the line of the runway lights spaced at 3 meters (10 feet) intervals toward the center. The line of threshold and runway end lights may be offset no more than 1.5 meters (5 feet) from the end of the runway. The lights shall be red toward the runway and green toward the approach.

10.3. Taxiway Edge Lighting. The techniques for designing an emergency taxiway edge lighting system are generally the same as for a standard system except that the spacing is increased as follows:
10.3.1. Straight Sections: The spacing shall not exceed 66 meters (220 feet).
10.3.2. Curved Sections: The spacing shall not exceed 30 meters (100 feet).

10.4. Helipad Lighting. Emergency helipad lighting shall follow the standard configurations for perimeter, landing direction, and approach direction lighting except the adherence to light plane criteria is not required.

10.5. Fixtures. Fixtures may be omni-directional, bi-directional or uni-directional. Where uni-directional fixtures are employed, they must be aimed in the direction of the planned operation. If the operational direction changes they must be installed for the new direction. Uni-directional fixtures generally have better light output for the energy being consumed than the other types. Omni-directional fixtures meeting MIL-L-19661, Light, Marker, Portable, Emergency Airfield, Battery Operated, Type 1 may be used with filters as appropriate for the application. Uni-directional and bi-directional fixtures meeting FAA AC 150/5345-50, Portable Runway Lights, may also be used. Other portable fixtures that are suitable for outdoor use, meet the duty cycle requirements and which meet or exceed the light output of the specified fixtures may be considered.

10.6. Controls. The specified lights have individual on/off controls and are not capable of control from a central point. They may have been provided with a flashing mode which shall not be used during periods when aircraft operations are being conducted.

10.7. Compliance With International Military Standards. These standards comply with NATO STANAG 3534, Airfield Portable Lighting Systems, and ASCC AIR STD 65/8, Airfield Portable Lighting Systems, except for light output of the fixtures.

PART 2 - SYSTEM INFORMATION

Chapter 11

DESIGN AND INSTALLATION GUIDELINES

11.1. Special Air Force Requirements:

11.1.1. General Guidelines. When design options exist and operational requirements do not dictate a clear choice between them, base the decision on the results of a life cycle cost analysis rather than the lowest first cost. All interior and exterior elements of the airfield lighting systems shall meet the requirements of this manual.

11.1.2. Light Fixture Mounting. Wherever practical, mount the light fixtures on bases installed in a concrete envelope. The mounting bases support the light fixture and normally house the isolation transformer. For temporary construction the light fixtures may be stake mounted, and the transformers may be surface mounted.

11.1.3. Cable Installation. Wherever practical, run all cables underground. They shall be suitable for underground installation, and installed either in concrete encased or direct buried duct. Use concrete encased duct under paved areas. When installation under existing pavement is required, the designer must select the best conduit for the application considering strength and corrosion resistance. For temporary construction, the cables may be direct buried. Make connections between the lighting cable, isolation transformers, and light fixtures with watertight connectors and stress cones. Cables for taxiway centerline, runway centerline and touchdown zone lights may be installed in conduit or in saw kerfs cut in the pavement. While direct installation in saw kerfs is permitted, ensure the cable is constrained below the pavement surface and protected from damage resulting from differential expansion or movement.

11.1.4. Grounding System. Provide a continuous counterpoise of number 4 (minimum) AWG bare, stranded copper wire over the entire length of all primary circuits supplying airfield lighting:

11.1.4.1. Counterpoise Criteria. Lay the counterpoise halfway between the runway/taxiway if at all possible. If not, lay it above the uppermost layer of direct buried ducts, or on the top of the concrete envelope of an encased duct bank. Provide only one counterpoise wire for cables in the same duct bank. Connect all counterpoise wires leading to a duct bank to the single counterpoise wire for the duct bank. Lay the counterpoise at least a third of a meter (0.3 meters) (12 inches) from any light cans. Connect the counterpoise by a number 6 AWG bare stranded copper wire to the lighting vault power grounding system at one point. Use brazing or thermoweld for all connections.

11.1.5. Frangibility and Accident-Avoidance Construction. In the areas around the runway, including the approach zone, all above-grade structures shall be lightweight and of a frangible or low impact resistant construction using breakaway sections to minimize hazards to aircraft. Concrete foundation or mounting slabs shall not extend above the finished grade of the surrounding surface.

11.1.5.1. ALSF Frangibility. A slight trade-off in frangibility can result in a significant savings in energy. Older ALSF systems use 300 watt lamps in the outer 600 meters (2,000 feet) to satisfy the photometric requirements which can actually be met with newer 200 watt lamps. However, the 200 watt lamps are rated at 6.6 amps rather than 20 amps and their use would require a change in isolation transformers. This would not be difficult in major renovations or new installations except that an additional eight wires must be installed in all low impact resistant and semi-frangible light supports. The MAJCOM may accept the slight loss of frangibility in order to achieve the energy savings.

11.1.6. Airfield Lighting Vaults. Vaults constructed in the past generally had a primary service of 4160/2400 volt, 3 phase, 60 hertz power. For new construction or major modernization, consider the following:

11.1.6.1. Use 480 volts as a primary voltage within the vault.

11.1.6.2. Main Lighting Vault. The main airfield lighting vault should contain power distribution and control equipment for runway and taxiway lighting circuits and any other lighting circuits that can feasibly use this source. It also should provide adequate space for the maintenance of the systems. Auxiliary vaults may be required for other airfield systems depending on the airfield configuration. Locate the vaults above grade in locations which are the most suitable as supply points.

11.1.6.3. Approach Lighting Vault. The approach lighting vault houses power distribution and control equipment primarily for the approach lighting and sequenced flashers, but other lighting systems nearby may also use this vault as a power source. Locate the vault adjacent to the approach zone at a sufficient distance to satisfy obstruction criteria.

11.l.6.4. Floor Mounted Equipment. All floor mounted equipment shall be securely bolted to the floor to prevent movement during seismic disturbances.

11.1.7. Emergency Power. Provide an emergency generator or other independent power source at each vault which services systems requiring standby power for continuous operation if the principal power source fail:

11.1.7.1. Engine Generator (E/G). Where engine generators are installed, provide a separate room or shelter with independent ventilation. Make provision for engine exhaust to the exterior of the shelter. Mufflers may be installed inside or outside the building. If installed inside, they must be insulated. Engine cooling may be provided by externally-mounted radiators or by use of a radiator duct to an external exhaust louver. Make provisions for mounting and cooling resistive load banks for diesel engine testing if the station load is inadequate or cannot be made available for engine testing. Provide fuel storage capacity for 72 hours of uninterrupted operation of the standby power system. Also provide automatic starting and switching capable of supplying the rated load within 15 seconds of a power failure except where CAT II instrument operations are conducted. During CAT II instrument operations, a one second power transfer is required. This is normally done by providing a remote start capability which permits operation of the lighting systems on the engine generator during Category II weather conditions. Standby power availability is then subject only to switching time. The actual procedure used must be locally coordinated. See FAA Advisory Circular 150/5340-17, Standby Power for Non-FAA Airport Lighting Systems, for additional information. Provide an automatic battery charger for the starting batteries. Isolate the E/G foundation slab to reduce vibration and noise transmission to other parts of the vault.

11.1.8. Independent Power Sources. An alternate independent power source qualifies as emergency standby power only if it is generated by a separate power generating station and routed over separate power lines. In most cases in the past, careful investigation revealed that seemingly independent sources were so inter-connected that failure of one could result in failure of the other. Exercise extreme care when determining the qualifications of alternate power sources before opting against an engine/generator for standby power.

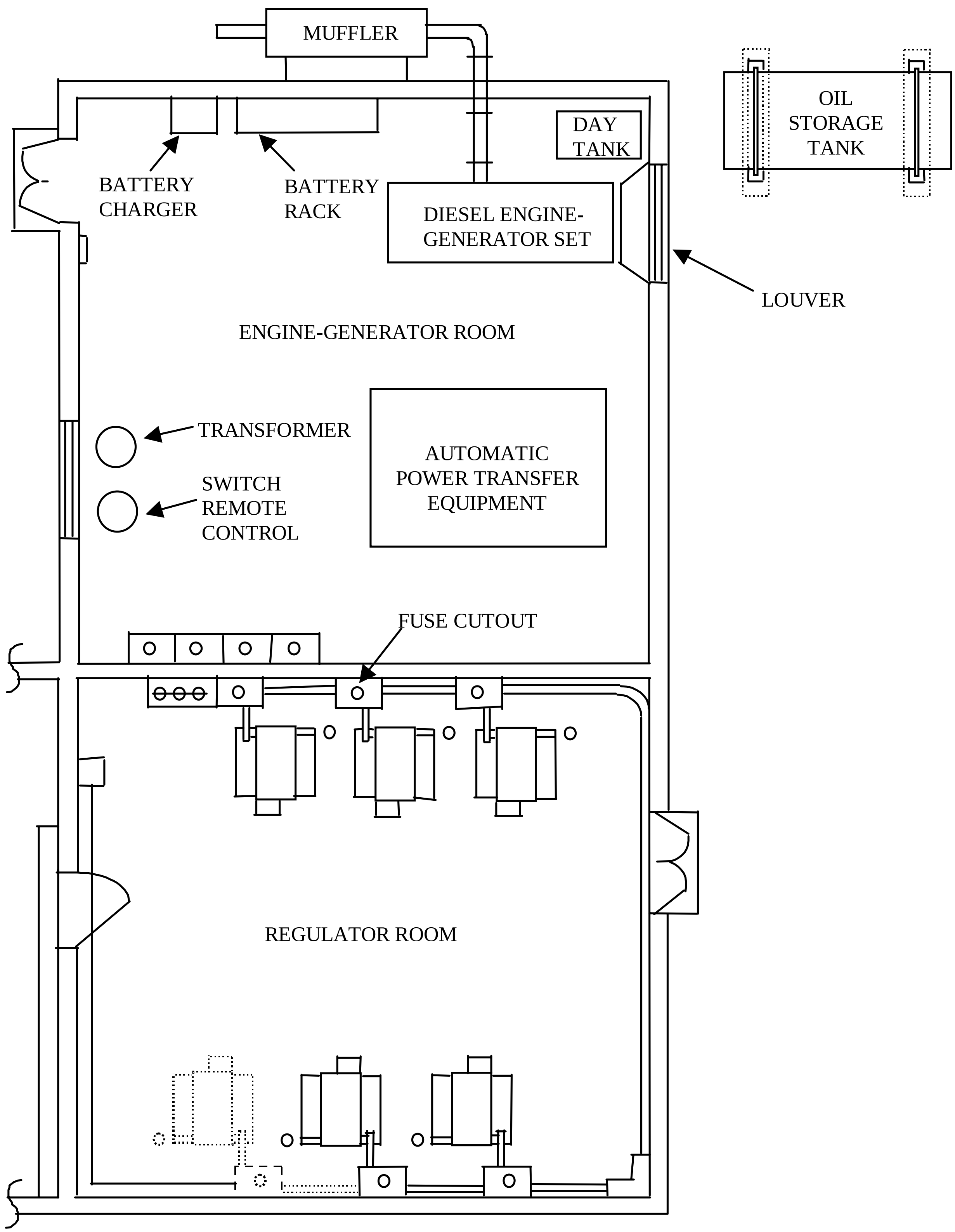
11.1.9. Airfield Lighting Control. The control system for airfield lighting consists of control panels, relaying equipment, accessories, and circuits which energize, de-energize, select lamp brightness, and otherwise control various airfield lighting circuits based on operational requirements. Control of any one airfield lighting system is normally provided at two points only: the control tower and the vault which powers the system. See figure 11.1 for a typical lighting vault block diagram. A transfer relay assembly is provided at the vault to transfer control from the remote location to the vault when necessary:

11.1.9.1. Control Voltages. Standard practice is to provide a 120 VAC control system using low burden pilot relays (pilot relay assemblies) to activate the power switches, contacts, and relays controlling the regulators and transformers supplying power to the airfield lighting circuits. The maximum horizontal distance from the control tower to the lighting vault is limited, for proper function of the pilot relay assemblies, to 2,240 meters (7,350 feet) when using 120 VAC control systems. Where the distance between the tower and the vault exceeds the maximum, consider using a 48 VDC control system as described in FAA AC 150/5340-24. Where both types of control system are installed, ensure the control power systems are isolated. (See figure 11.2).

11.1.9.2. Control Circuitry. Design the control system to ensure the following:

- Lighting on intersecting runways cannot be energized simultaneously.
- All circuits supplying the lights for any one lighting system (for example, runway edge lighting) are energized simultaneously and operated at the same brightness step.
- Runway centerline lights cannot be energized unless the runway edge lights are energized.
- Touchdown zone lighting (TDZL) cannot be energized unless the runway centerline lights are energized.

Figure 11.1. Installation Plan, Power Equipment.



11.1.9.3. Control System Modernization. Major commands are encouraged to consider, during the design process, the use of multiplex or other state-of-the-art control systems, where significant economies or operational improvements can be achieved. If an approved specification is not available, the use of such systems is subject to the requirements of paragraphs 12.6 and 1.8 of this manual. Control systems using electromagnetic emissions also require the express approval of HQ AFCESA/CESE.
11.1.10. Light Colors. For colors of light, see the applicable FAA Advisory Circular, and the Chromaticity (CIE) color coordinate diagram at figure 12.2.
11.1.11. Light Intensity:
(1) The brightness steps for the levels of lamp intensity are shown in table 11.1.

Figure 11.2. Power and Control System Block Diagram.

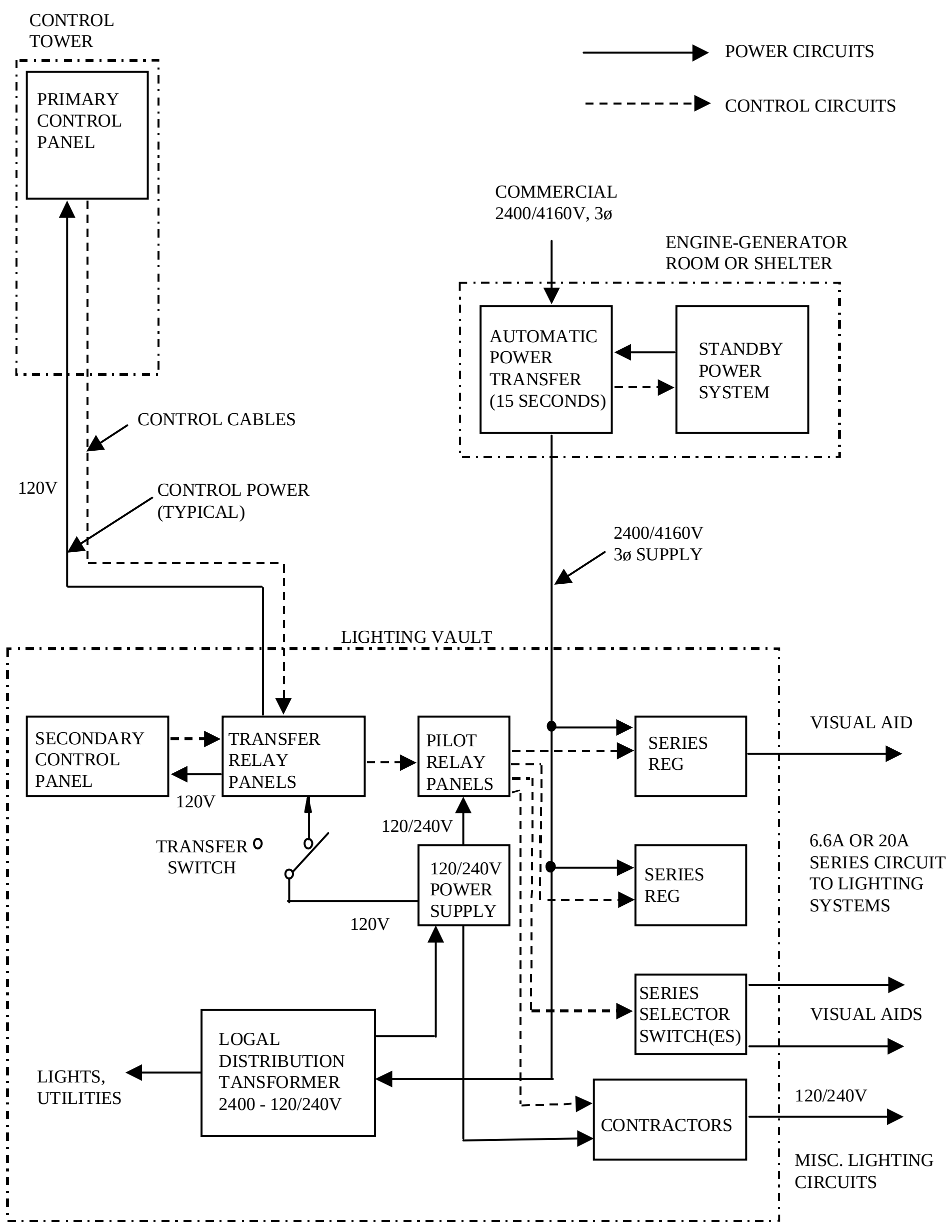


Table 11.1. Intensity Requirement Levels for Various Circuits.

BRIGHTNESS STEP	AMPERAGE READING 20-AMPERE CIRCUIT	AMPERAGE READING 6.6-AMPERE CIRCUIT	APPROXIMATE PERCENT RATED INTENSITY
1	7.5	2.8	0.16
2	10.3	3.4	0.80
3	12.4	4.1	4.00
4	15.8	5.2	20.00
5	20.0	6.6	100.00

(2) The brightness steps for three levels of lamp intensity are achieved by varying the current in the lighting circuit as follows:

Brightness Level	**Service Systems Lamp Current (amps)**	**Percent Brightness**
High	6.6	100
Medium	5.5	30
Low	4.8	10

11.2. Additional Guidance:

11.2.1. General. The FAA has published guide specifications for installation of airfield lighting systems. FAA guide specifications come in two forms: advisory circulars in the 5340 series and FAA-C specifications. A listing of applicable publications is provided below. Where those guides are in conflict with the Air Force requirements listed above, the Air Force requirements take precedence. The FAA has an Advisory Check List AC 00-X.X that provides a list of documents, and how to order them. Contact the FAA at 1-800-FAA-SURE, (fax: 301-386-5394).

11.2.2. FAA Advisory Circulars. FAA advisory circulars may be obtained from the Department of Transportation. Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, Maryland, 20785. Request latest editions (A, B, C, etc.): (Fax: 301-386-5394).

11.2.2.1. AC 150/5340-4. Installation Details for Runway Centerline Touchdown Zone Lighting Systems. Describes standards for the design and installation of runway centerline and touchdown zone lighting systems.

11.2.2.2. AC 150/5340-17. Standards For Airport Sign Systems. Describes the recommended standards for design and installation of a taxiway guidance sign system.

11.2.2.3. AC 150/5340-21. Airport Miscellaneous Lighting Visual Aids. Describes standards for the system design, installation, inspection, testing and maintenance of airport miscellaneous visual aids, i.e., airport beacons, beacon towers, wind cones, wind tees, and obstruction lights.

11.2.2.4. AC 150/5340-24. Runway and Taxiway Edge Lighting System. Describes standards for the design, installation, and maintenance of runway and taxiway edge lighting.

Chapter 12

QUALIFYING EQUIPMENT

12.1. General Equipment Requirements. This chapter covers equipment and equipment specifications which meet the standards in the first part of this manual. The chapter includes only those items covered by the associated standards and does not include cables, auxiliary or main power generating systems, or common use items such as convenience outlets or interior electrical fixtures.

12.2. Existing Facilities. Do not use this instruction as a sole basis for advancing standards of existing facilities and equipment, except where necessary for a minimum acceptable level of safety, quality, and performance. You may continue to support existing systems with equipment fabricated to the original specifications until the system is upgraded. If mixing of new generation equipment with older equipment is required, make sure the difference in performance does not degrade the system in any way.

12.3. Equipment Specifications. The equipment specifications used in this chapter fall into two broad categories: FAA Advisory Circulars (AC) and FAA-E Series specifications (FAA-E-XXXX). Users of this manual should assure themselves that the performance characteristics, particularly light output and aiming, are compatible before choosing to mix military existing fixtures with FAA type equipment of the same category (e.g., elevated runway edge lights) in a single runway, taxiway, or approach lighting system. Use the latest edition of a specification if the performance requirements continue to satisfy the appropriate standard in part one of this regulation. If specifications are canceled and replaced by specifications with new numbers, use the new specification if the applicable standards of this regulation are met.

12.4. Qualified Products. The FAA maintains lists of manufacturers of products meeting Advisory Circular specifications. For equipment meeting FAA Advisory Circular specifications use FAA AC 150/5345-53, Airport Lighting Equipment Certification Program. Qualification or approval in listing does not mean automatic acceptance of the equipment for a particular project. Satisfactory evidence of the production tests included in the specifications is required for acceptance for each project. There are no qualified products lists for equipment manufactured to FAA-E specifications. Information concerning current sources of this equipment may be obtained from regional FAA offices and manufacturers product literature. The specified production tests are also required for these products.

12.5. Commercial Equipment. Commercial equipment, not covered by appropriate military or FAA specifications, must meet applicable industry standards such as the National Electrical Manufacturers Association (NEMA), Institute of Electrical and Electronic Engineers (IEEE), etc. Contract documents must specify the methods for verifying conformance.

12.6. Alternative Equipment. You may consider equipment using new technologies but must make sure the standards in this manual are met; that cost effectiveness, reliability, availability, maintainability, and service life are not compromised; and adequate training and logistic support for the substitute equipment is available. The waiver requirements of paragraph 1.8 apply.

12.7. Emergency Substitution. In emergency situations where facility restoration would be significantly delayed by non-availability of replacement parts, equipment or devices not meeting the applicable specifications may be substituted. Base Civil Engineering, airfield operations, and flying safety offices must all coordinate on these substitutions and notify the MAJCOM. Remove the substitute equipment from service and replace it with approved equipment as soon as it becomes available.

12.8. Common Use Airfield Lighting Equipment. This paragraph lists equipment commonly used in most or all airfield lighting system installations. Wherever required, listed equipment conforming to the cited specifications may be used. Other special application equipment is specified in the paragraphs covering the particular lighting system involved:

12.8.1. Control Panels. Use panels meeting FAA AC 150/5345-3, Type L-821. Tower cab design constraints or special air traffic controller requirements may dictate the use of other types of control panel.

12.8.2. Pilot Relay Cabinets. Use cabinets meeting FAA AC 150/5345-13, Type L-84l for 48 VDC control systems.

12.8.3. Transfer Relay Panels. Use panels meeting MIL-C-4971.

12.8.4. Series Circuit Selector Switches. Use switches meeting MIL-D-4806, or FAA AC 150/5345-5 Type L-847.

12.8.5. Control Transfer Panels. Use panels meeting MIL-P-4971, Type MB-1.

12.8.6. Control Cables. Control cables for 120 VAC control systems shall be multi-conductor, 600 volts, 12 AWG, rated for direct earth burial. Cables for 48 VDC control circuits shall be multi-conductor, stranded 19 AWG, with 300 volt polyvinyl insulation suitable for installation in wet locations and meeting REA Bulletin 345-14 or 345-67. All conductors shall be color coded.

12.8.7. Current Regulators. Use regulators meeting FAA AC 150/5345-10 of a suitable type and style. The size selected should normally provide for approximately 20 percent expansion of the load.

12.8.8. Engine/Generators. Use engine/generators meeting Specification FAA-E-2204 with Type I automatic power transfer. Also see AFI 32-1063, Electric Power Systems, and AFMAN 32-1077, Engines and Generators.

12.8.9. Series Cable Selection. Cables shall be unshielded, 5000 volt ethylene-propylene FAA AC 150/5345-7 (Latest Issue) L-824, type B insulation and include an overall jacket of cross-linked polyethylene unless waivered by the MAJCOM. Series cables (medium voltage, 5000 volt) shall not be installed in cable trays unless they are rated TC.

12.8.10. Connectors. Use connectors meeting FAA AC 150/5345-26, for L-823 plug and receptacle cable connectors to interconnect fixtures, isolation transformers, and distribution cables.

12.8.11. Isolation Transformers. Use isolation transformers meeting FAA AC 150/5345-47. When specifying, ensure the input/output currents are compatible with the regulator and current rating of the lamp.

12.8.12. Mounting Bases and Transformer Housings. Use bases meeting FAA AC 150/5345-42. When specifying FAA type bases, use Type L-867 for non-traffic areas and Type L-868 for load bearing applications. Unless otherwise specified non-metallic bases may be used in non-load bearing applications. Ensure the base and fixture are compatible.

12.8.13. Frangible Supports. If frangible mounting is required and the device is not provided with an integral fracture mechanism, mount the device on electric metallic tubing (EMT) or intermediate metallic conduit (IMC) attached to the mounting base by a frangible coupling meeting FAA Drawing C-6046A.

12.8.14. Fixtures, Filters and Lamps. Use fixtures and lamps as specified for each system. If more than one fixture is connected to an isolation transformer, the fixture shall have a shorting device or bypass relay to avoid multiple light outage if a lamp fails. Filter colors shall meet the latest FAA Advisory Circular criteria, also refer to the CIE color coordinate diagram. (See figure 12.1).

12.9. Equipment for Approach Light Systems:

12.9.1. High Intensity Approach Light System ALSF-1, reference paragraph 3.1.

12.9.1.1. Pre-threshold Bar, use fixtures meeting FAA-E-982 with red filters. (See figure 12.2).

Figure 12.1. CIE Color Coordinate Diagram.

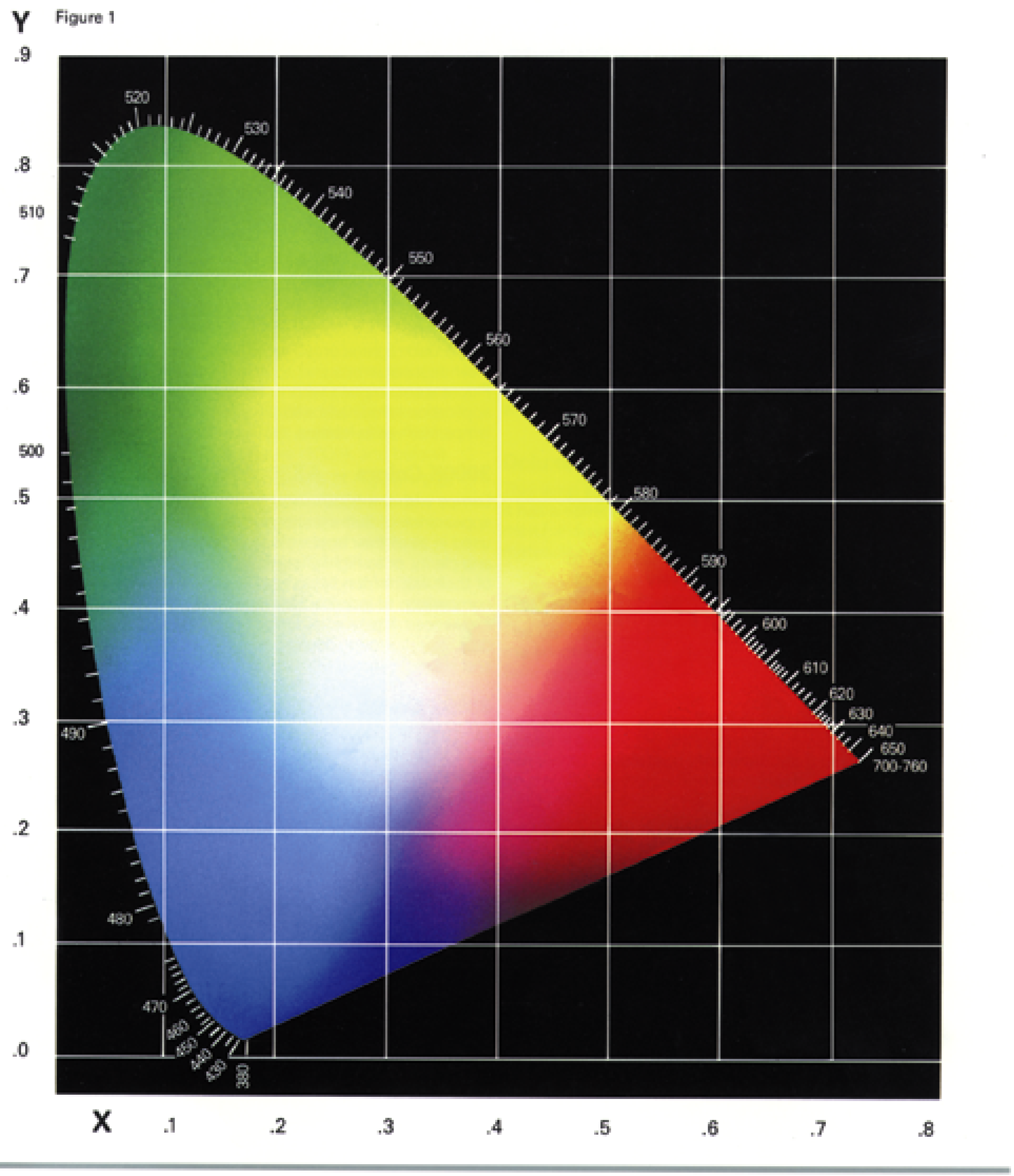
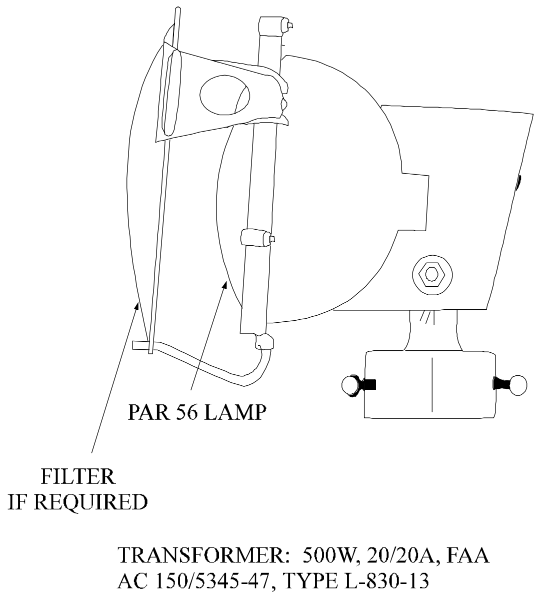
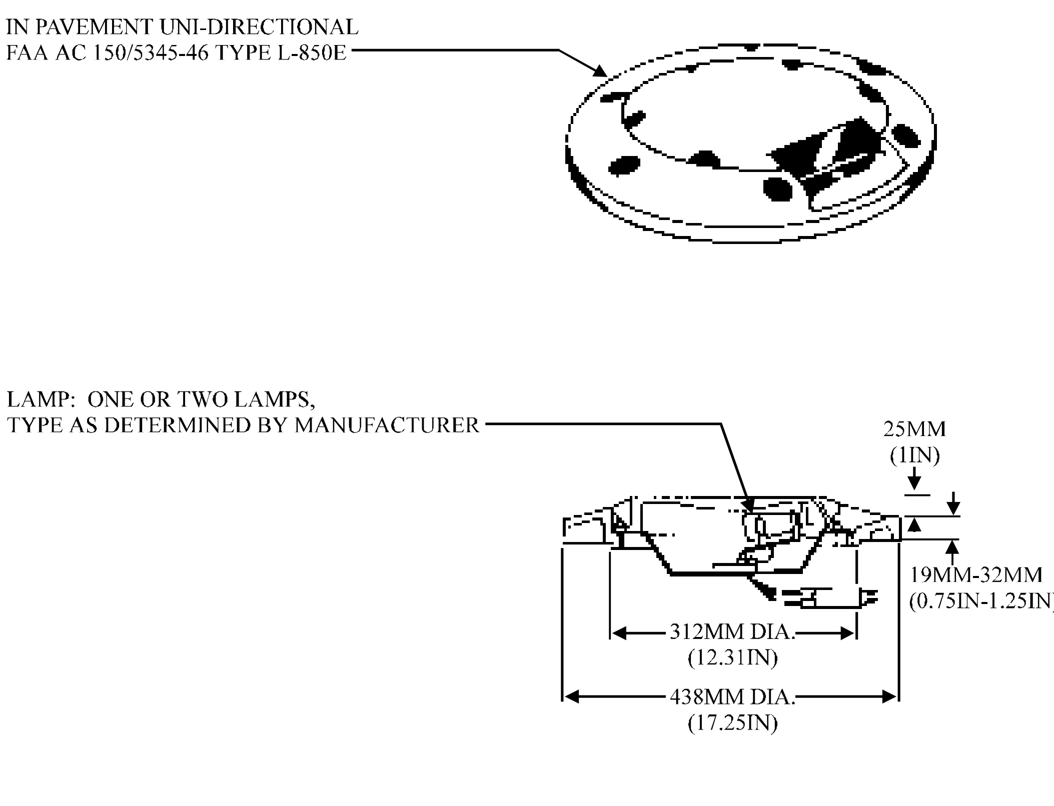


Figure 12.2. FAA-E-982, Elevated, Uni-Directional, PAR-56, Lamp Holder.



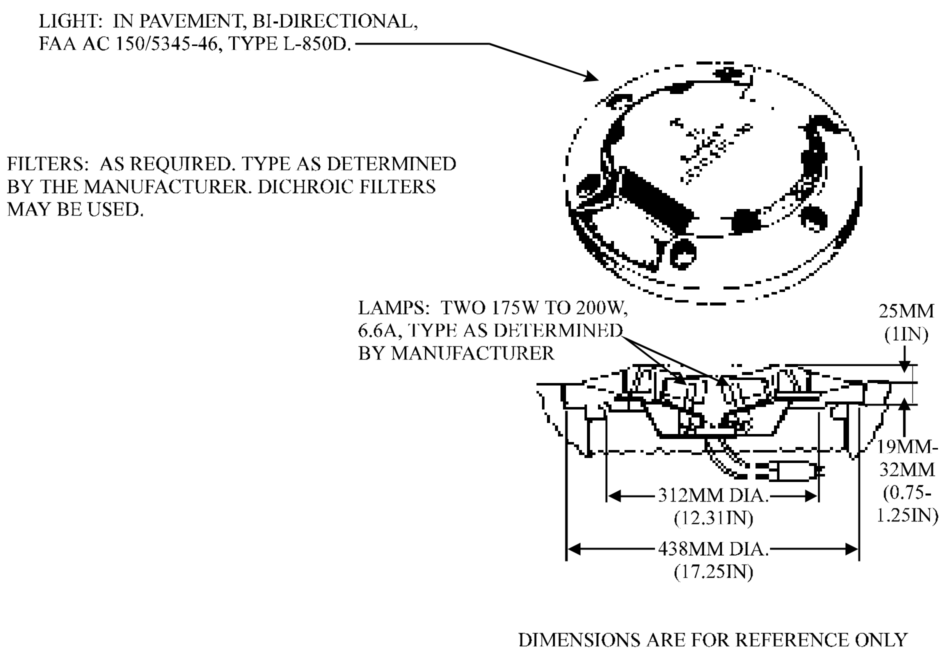
12.9.1.2. Terminating bar, use fixtures meeting FAA-E-982 with red filters. (See figure 12.2).
12.9.1.3. 1,000-foot crossbar, use fixtures meeting FAA-E-982 with no filter. (See figure 12.2).
12.9.1.4. Centerline light barrettes, use fixtures conforming to FAA AC 140/5345-46, type L-850 without filters. (See figure 12.3).

Figure 12.3. FAA-L-850E, In Pavement, Uni-Directional.



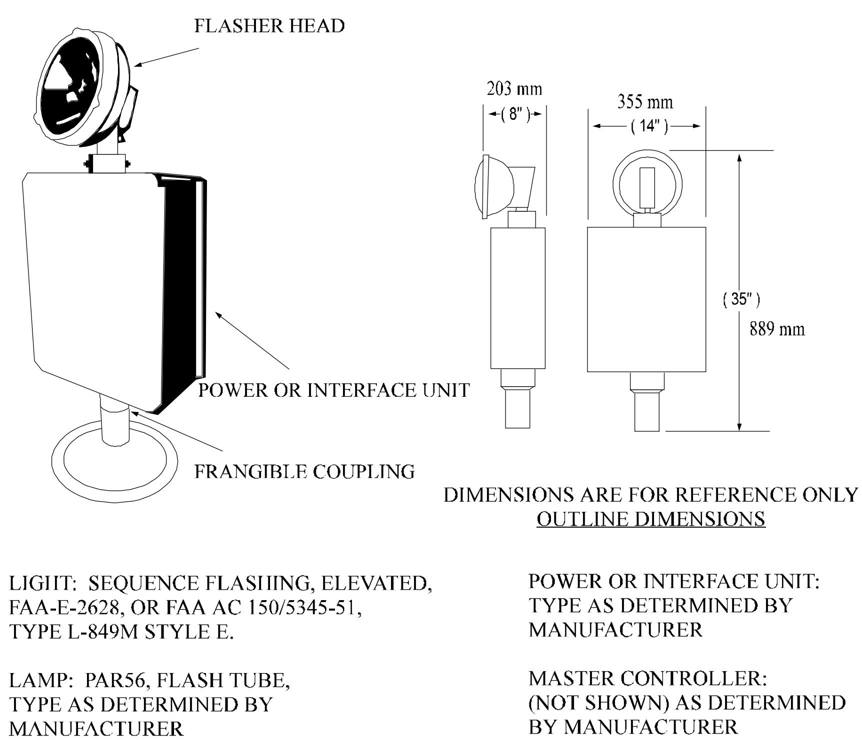
12.9.1.5. Centerline light barrettes, for stations 10+00 to station 30+00, and for unpaved end zone areas use fixtures meeting FAA-E-982 without filters. (See figure 12.2).
12.9.1.6. Approach Threshold Lights, use fixtures conforming to FAA AC 150/5345-46 type L-850E or D with green filters or red/green filters. (See figure 12.4).

Figure 12.4. FAA-L-850D, In Pavement, Bi-Directional.



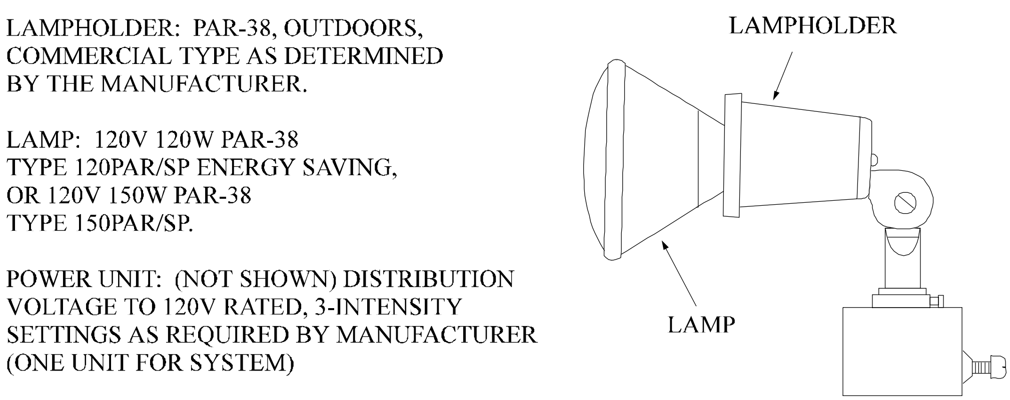
12.9.1.7. Sequence Flashing Lights SFL, use fixtures meeting FAA-E-2628 type I or conforming to FAA AC 150/5345-51 type L-849 type E. (See figure 12.5).

Figure 12.5. FAA-E-2628, or FAA L-849E, Elevated, Condenser Discharge (SFL).



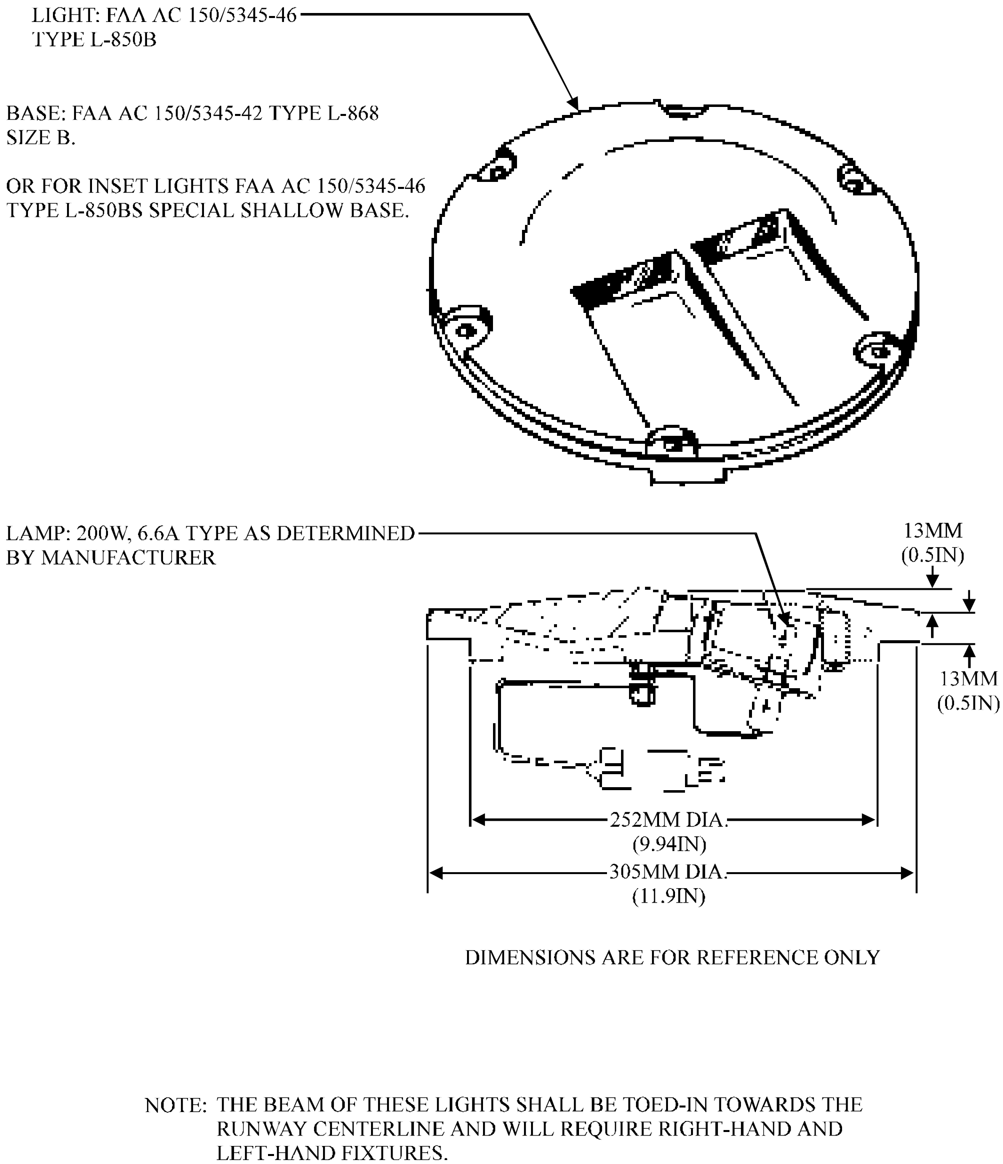
12.9.2. High Intensity Approach Light Systems ALSF-1, reference paragraph 3.1. This system is a modified ALSF-1 system, the following areas have additional light fixtures:
12.9.2.1. 500 foot bar, use fixtures conforming to FAA AC 150/5345-46, type L-850E without filters, see figure 12.3. If the end zone is not paved use fixtures FAA-E-982, see figure 12.3.
12.9.2.2. Side Row lights, use fixtures meeting FAA-E-982, with red filters. (See figure 12.2).
12.9.3. Short Approach Lighting System (SALS):
12.9.3.1. This system is a shortened version of the ALSF-1 system, the same fixtures as in figure 12.2 are used.
12.9.4. Simplified Short Approach Light System with Runway Alignment Indicators.
12.9.4.1. This system is a simplified version of the ALSF-1 and ALSF-2 systems, the same fixture as in figures 12.2 and 12.3 are used.
12.9.5. Medium Intensity Approach Light System with Runway Alignment Indicator lights (MALSR), reference paragraph 4.5.3.
12.9.5.1. Centerline light barrettes, use fixtures meeting FAA-E-2325, PAR 38 lamp holders. (See figure 12.6).

Figure 12.6. FAA-E-2325, Elevated, Uni-Directional, PAR-38 Lamp Holder.



12.9.5.2. 1,000-foot crossbar, same as paragraph 12.9.5.3.
12.9.5.3. Runway Alignment Indicator lights (RAIL), use fixtures conforming to FAA AC 150/5345-51, type L-849E. (See figure 12.5).
12.9.5.4. Paved areas, when the system is installed in a paved over run area, use fixtures conforming to FAA AC 150/5345-46 type L-850B. (See figure 12.7).
12.9.5.5. General Lamp Guidelines. Use lamps recommended by the manufacturer to meet the requirement. Different manufacturers may meet the requirement using different lamps. In the interest of energy conservation, the lower wattage lamps are preferred. When using lamps rated at 6.6 amps, they must be connected to individual 6.6/20A isolation transformers. When using lamps rated at 20A, they shall be connected to individual isolation transformers if the mounting height of the fixture is 2 meters (6 feet) or less. If the overall mounting height is greater than 2 meters (6 feet), the lights in a bar shall be connected in series to the transformer specified in paragraph 12.9.5.7. Fixtures connected in series to a single isolating transformer shall have bypass relays to bypass failed lamps.

Figure 12.7. FAA-L-850B, In Pavement, Uni-Directional.

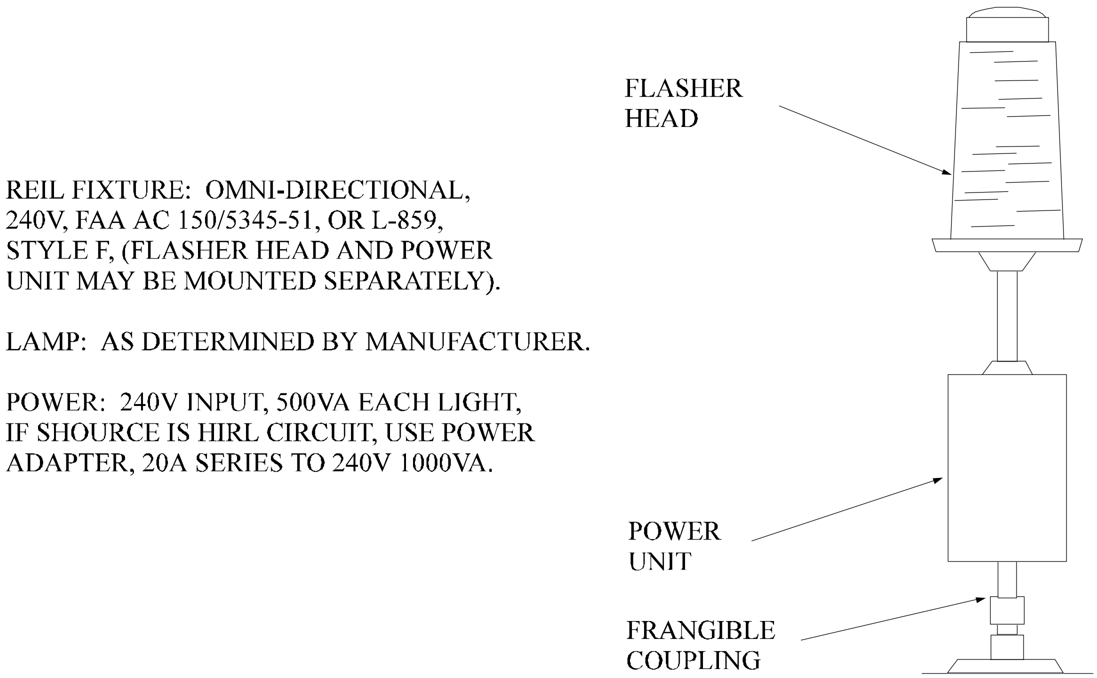


12.9.5.6. Light Fixture Supports. Light fixtures supports for mounting fixtures up to 2 meters (6 feet), use .05 meters (2 inch) diameter EMT which is fitted at the bottom with a frangible coupling conforming to FAA Drawing C-6046A. For light fixtures elevated between 2 meters (6 feet) and 12 meters (40 feet) above ground level (AGL), use glass reinforced plastic fiber approach light support towers meeting FAA-E-2702 and FAA Drawing Series D-6155. For light fixtures elevated more than 12 meters (40 feet) AGL, use 6 meters (20 feet) telescoping masts meeting FAA-E-2702 and FAA Drawing Series D-6155 which are installed on rigid supports. For rigid supports for fixtures over 12 meters (40 feet) AGL, use structural steel supports fabricated to FAA-E-910G and FAA Drawing Series D-6076 to support the 6 meters (20 feet) telescoping light supports.

12.9.5.7. Isolation Transformers (1500W). Isolation Transformers for 20A rated lamps, elevated more than 2 meters (6 feet) AGL are 1500W meeting FAA-E-2690.

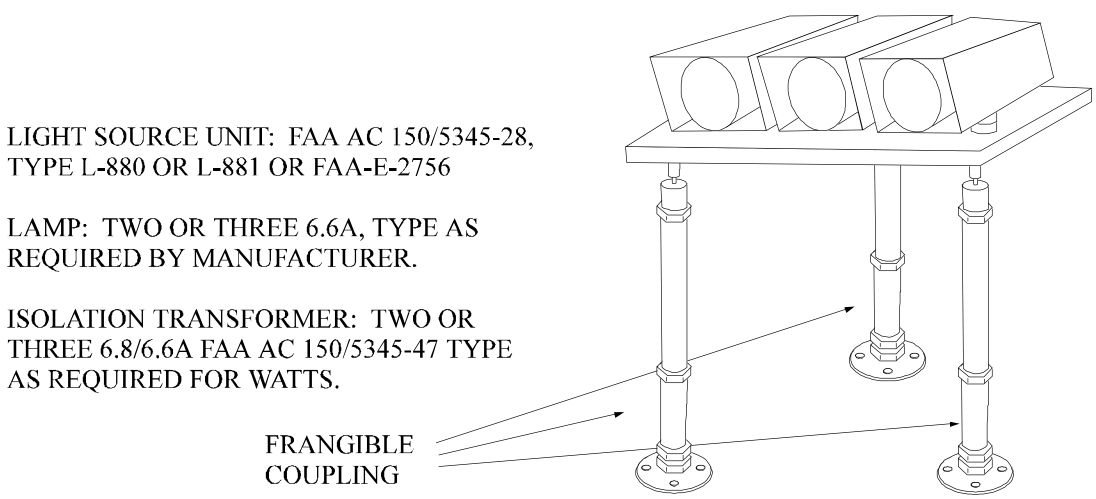
12.9.6. Runway End Identifier Lights (REIL). Reference paragraph 3.6. Use equipment meeting FAA-E-2628B or FAA AC 150/5345-51, Type L-859F for Omni-directional REIL installations. (See figure 12.8).

Figure 12.8. FAA-L-859F, Omni-Directional, Flashing.



12.9.7. PAPI. Reference paragraph 3.7. Use equipment meeting FAA-E-2756 or FAA AC 150/5345-28, type L-880, Precision Approach Path Indicator (PAPI) Systems, Equipment and Installation. (See figure 12.9).

Figure 12.9. FAA L-880, or FAA-E-2756, PAPI or CHAPI System.

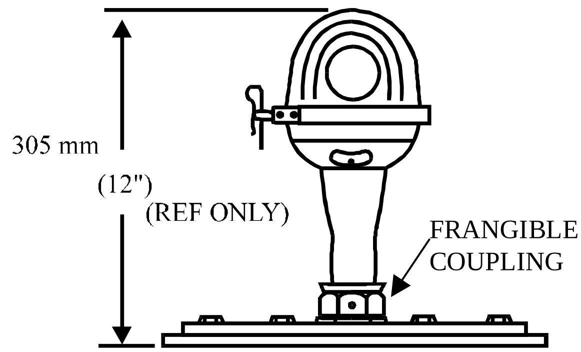


12.10. Equipment for Runway Lighting Systems:

12.10.1. High Intensity Runway Edge Lighting Equipment. Reference paragraph 4.2.

12.10.1.1. Elevated Fixtures. Use light fixtures meeting FAA AC 150/5345-46, Type L-862. (See figure 12.10). Colored filters, where required for displaced threshold areas, shall meet the requirements of the specification and be compatible with the fixture. Use lamps recommended by the manufacturer. Different manufacturers may meet the requirement using different lamps. In the interest of energy conservation, lower wattage lamps are preferred.

Figure 12.10. FAA L-862, Elevated, Bi-Directional.



LIGHT: ELEVATED HIRL FAA AC 150/5345-46
TYPE L-862

LAMP: 150W TO 209W 6.6A TYPE AS SPECIFIED
BY MANUFACTURER.

TRANSFORMER: FAA AC 150/5345-47 TYPE L-830-7.
IF FOR 6.6A PRIMARY CIRCUIT, 200W, 6.6/6.6A.

OR

FAA AC 150/5345-47 TYPE L-830-6

MAY BE MOUNTED ON LIGHT BASE OR CONDUIT
USE FRANGIBLE COUPLING.

12.10.1.2. In Pavement Fixtures. Use fixtures meeting FAA AC 150/5345-46, Type L-850C. (See figure 12.11). Use lamps recommended by the manufacturer. Different manufacturers may meet the requirement using different lamps. In the interest of energy conservation, lower wattage lamps are preferred.

12.10.2. Medium Intensity Runway Edge Lights. Reference paragraph 4.3.

12.10.2.1. Elevated Fixtures. Use fixtures meeting FAA AC 150/5345-46, Type L-861. (See figure 12.12). In displaced threshold areas, provide colored filters meeting the specification and compatible with the fixture.

12.10.2.2. In Pavement Fixtures. Use bi-directional fixtures meeting FAA AC 150/5345-46, Type L-852B without filters. (See figure 12.13). Use lamps recommended by the manufacturer. Different manufacturers may meet the requirement using different lamps. In the interest of energy conservation, lower wattage lamps are preferred.

Figure 12.11. FAA L-850C, In Pavement, Bi-Directional.

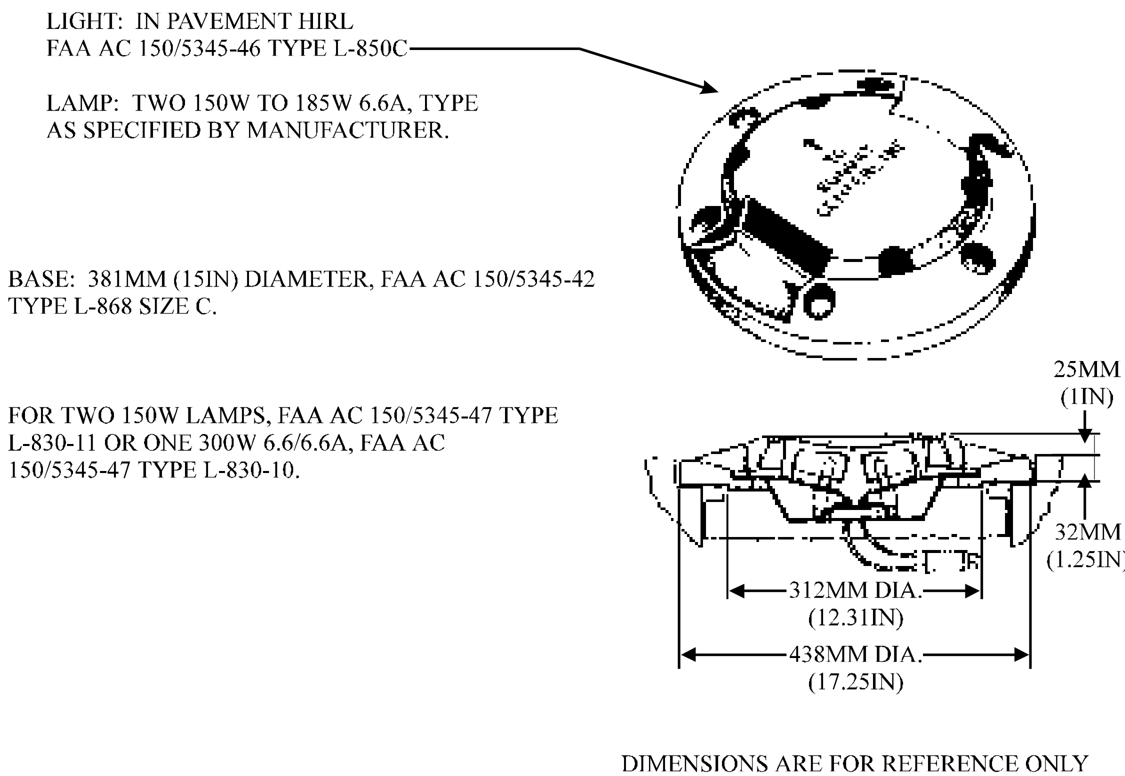


Figure 12.12. FAA L-861, Elevated, Omni-Directional.

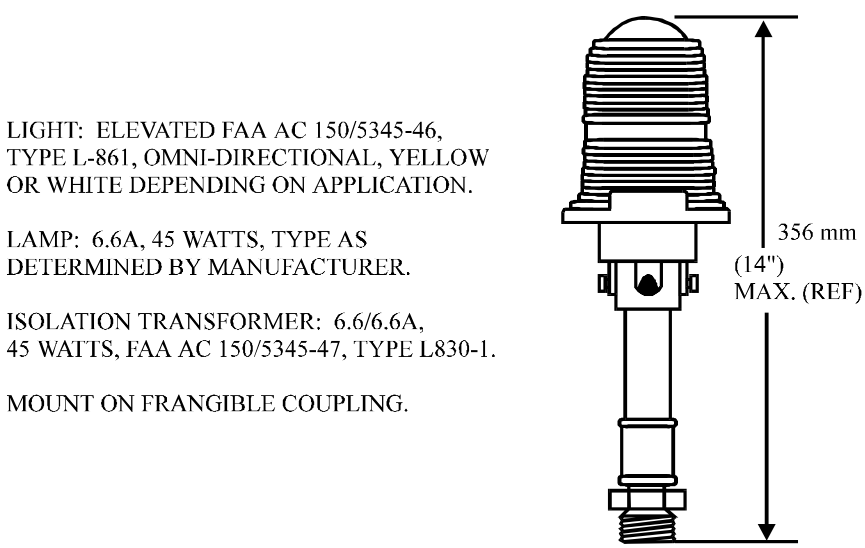
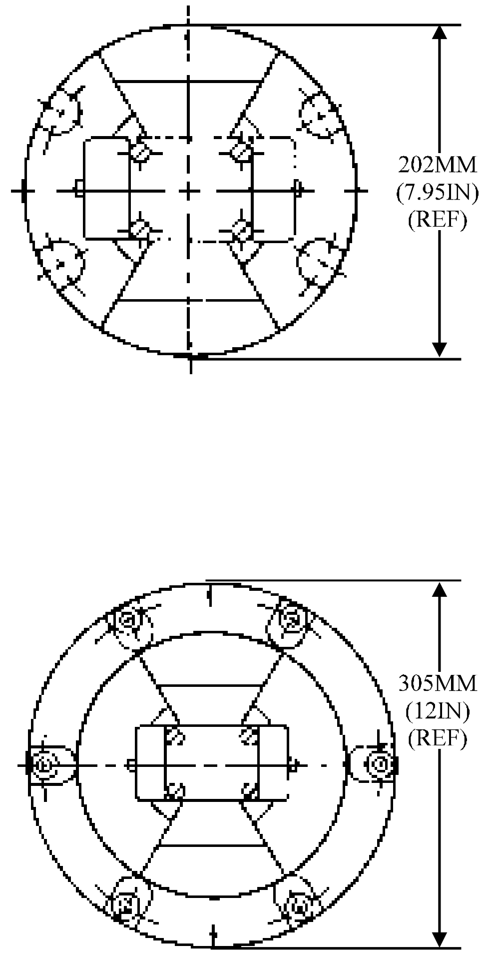


Figure 12.13. FAA L-852, (A, B, C, D), In Pavement, Bi-Directional.



LIGHT: SEMI-FLUSH, BI-DIRECTIONAL OR UNI-DIRECTIONAL, FAA AC 150/5345-46 TYPE L-852A,B,C, OR D, AS DETERMINED FOR NARROW-BEAM, WIDE-BEAM, OR CATEGORY III.

LAMP: 6.6A, WATTS AND TYPE AS DETERMINED BY THE MANUFACTURER.

FILTERS: AVIATION COLORS, TYPE AS DETERMINED BY APPLICATION.

12.10.3. High Intensity Threshold Lighting. Reference paragraph 4.4.

12.10.3.1. In Pavement Fixtures, Bi-Directional, Red/Green. Use light fixtures meeting FAA AC 150/5345-46, Type L-850D, when combination runway end light/threshold light fixtures are required. (See figure 12.5).

12.10.3.2. In Pavement Light Fixtures, Uni-directional, Green. Use light fixtures meeting FAA AC 150/5345-46, Type L-850E, when uni-directional threshold lights are required. (See figure 12.4).

12.10.3.3. Medium Intensity Threshold and End Lights. Use fixtures meeting FAA AC 150/5345-46, Type L-852D, with red and green filters where bi-directional runway end/threshold fixtures are required. If uni-directional light is required use a blank on the side not needed. (See figure 12.13).

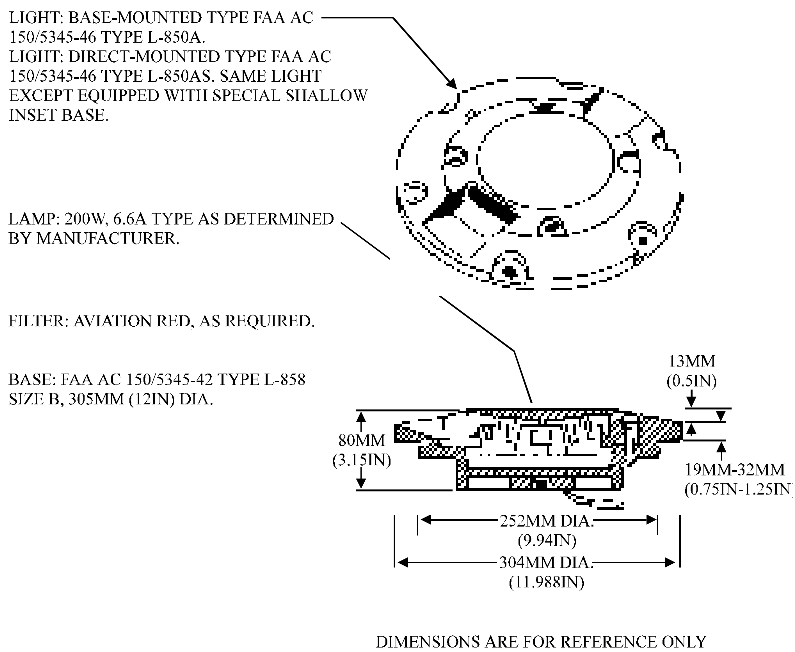
12.10.4. Runway End Lights (High Intensity). Reference paragraph 4.6.

12.10.4.1. Light Fixtures, In Pavement, Uni-directional, Red. Use fixtures meeting FAA AC 150/5345-46, Type L-850E with red filter where threshold and runway ends are not relocated. (See figure 12.4).

12.10.4.2. Light Fixtures, In Pavement, Bi-Directional, Red/Green. Use fixtures with red and green filters meeting FAA AC 150/5345-46, Type L-850D when runway end lights are co-located with threshold lights. (See figure 12.5).

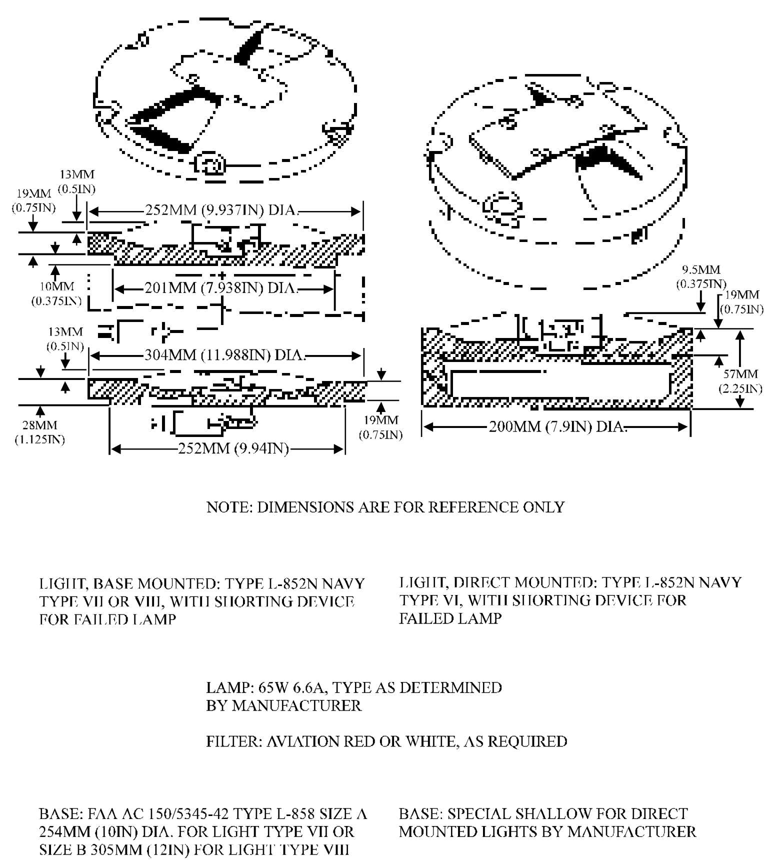
12.10.5. Runway Centerline Lights RCL. Reference paragraph 4.7. Use fixtures meeting FAA AC 150/5345-46, Type L-850A, Class I or II. Use red filters where required to meet the requirements in paragraph 4.7. (See figure 12.14).

Figure 12.14. FAA L-850A, In Pavement, Bi-Directional.



12.10.5.1. Where centerline lights are subject to aircraft tail hook impact use a high strength steel design designated as L-852N (NAVY). (See figure 12.15).

Figure 12.15. FAA L-852N, In Pavement, Bi-Directional (Hook-Resistant).



12.10.6. Touchdown Zone Light (TDZ). Reference paragraph 4.8. Use fixtures meeting FAA AC 150/5345-46, Type L-850B, Class I or II. (See figure 12.8).
12.10.7. Runway Distance Markers (RDM). Reference paragraph 4.9. Use markers meeting FAA AC 150/5345-44, Type L-858B, size 4. When connected to the runway lighting circuits, specify style 3. (See figure 4.16).
12.10.8. Arresting Gear Markers (AGM). Reference paragraph 4.10. These markers are a modified RDM with a yellow circle in lieu of a number. (See figure 12.16).

12.11. Equipment for Taxiway Lighting Systems:
12.11.1. Taxiway Edge Lights. Reference paragraph 5.1. Elevated Fixtures. Use light fixtures meeting FAA AC 150/5345-46, Type L-861T. (See figure 12.17). Use lamps recommended by the manufacturer to meet the requirements of paragraph 5.1. Different manufacturers may meet the requirement using different lamps. In the interest of energy conservation, lower wattage lamps are preferred.

Figure 12.16. FAA L-858B, Sign, Elevated, AGM.

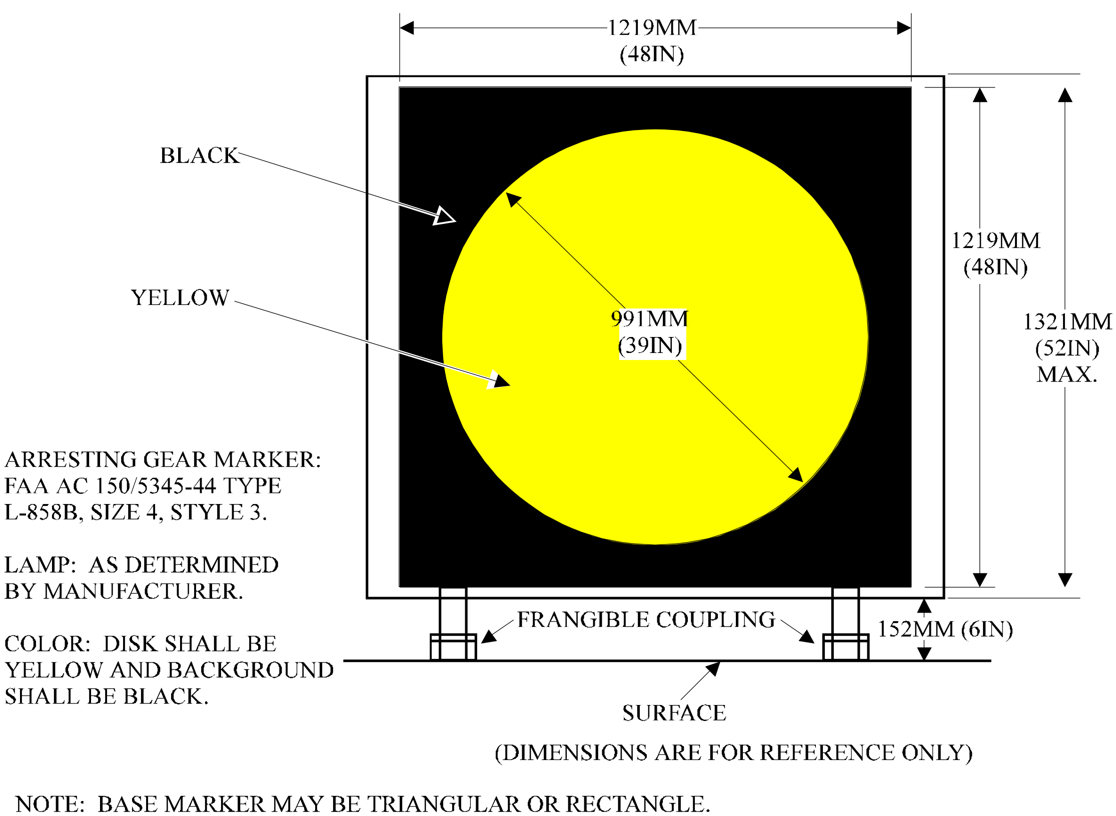
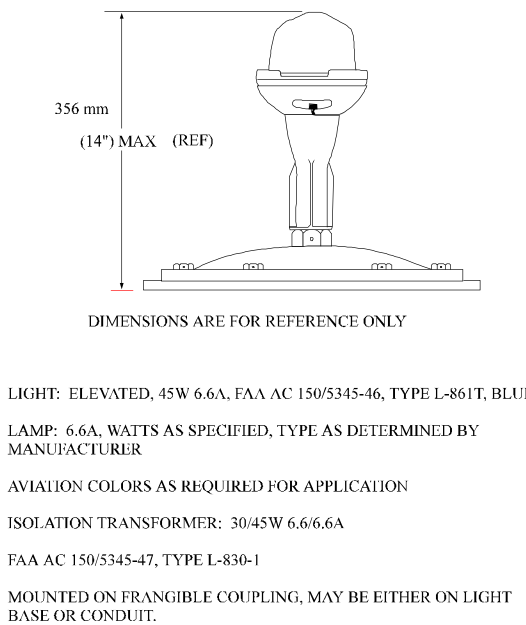
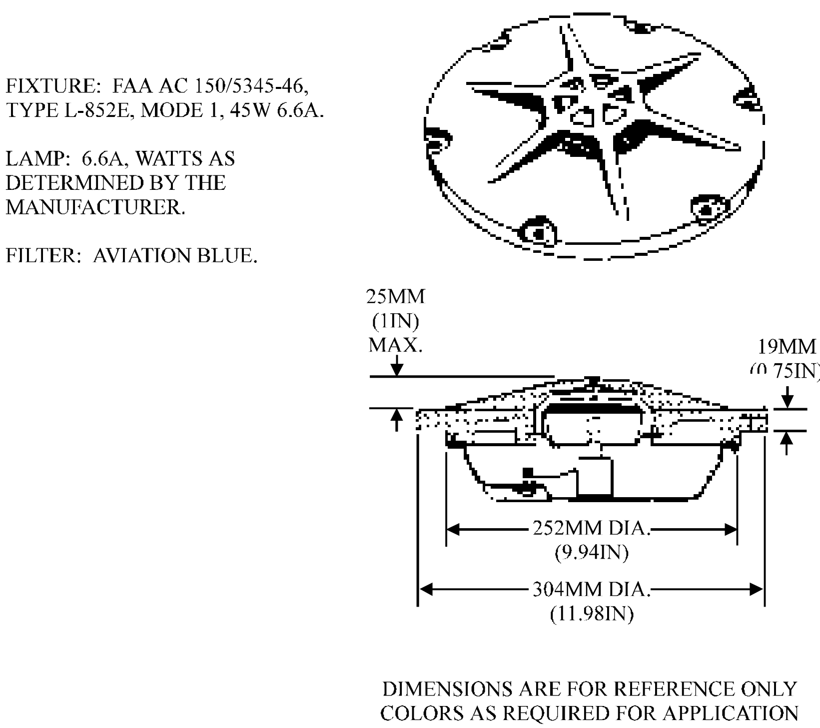


Figure 12.17. FAA L-861T, Elevated, Omni-Directional.



12.11.1.1. In Pavement Fixtures. Use light fixtures meeting FAA AC 150/5345-46, Type L-852E, class I or II with blue filters. (See figure 12.18).

Figure 12.18. FAA L-852E, In Pavement, Omni-Directional.



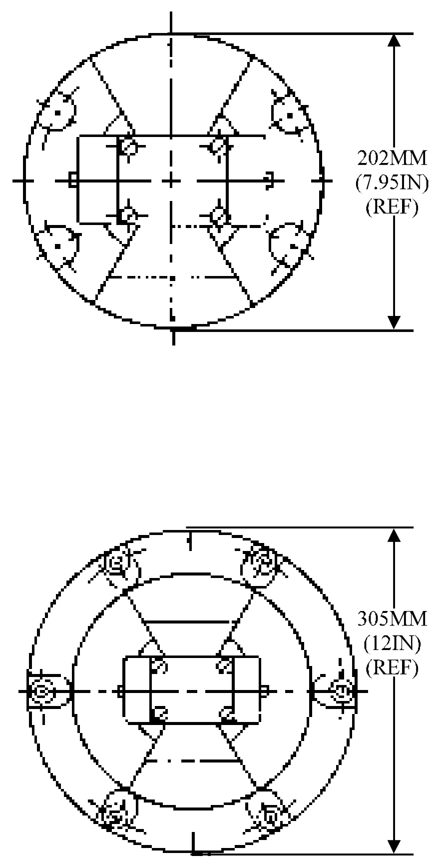
12.11.2. Taxiway Centerline, Hold and High Speed Turnoff Lighting. Reference paragraphs 5.2 and 5.4. (See figure 12.19).
12.11.2.1. Fixtures. Use fixtures meeting FAA AC 150/5345-46, Type L-852, Class I or II. These fixtures may be direct inset, for mounting on special shallow bases, or for mounting on 10 or 12 inch base housings. Select fixtures by type depending on application.
12.11.2.2. Straight Centerline Sections. For Category II and higher operations, use Type L-852A with green/green filters except at hold bars where the filter facing the holding aircraft will be yellow. For Category III application, use Type L-852C.
12.11.2.3. Curved Centerline Sections. For Category II and higher operations, use Type L-853B. Where small radius turns require aiming along a chord for proper viewing, two fixtures may be used. For Category III applications, use Type L-852D.
12.11.2.4. Hold Lights. Use Type L-852A with yellow filter for side lights at hold bar arrays for category and higher operations. For Category III applications, use Type L-852C.
12.11.2.5. High Speed Turnoff. For Category II and higher operations, Type L-853A uni-directional with green filter may be used on straight sections and L-852B uni-directional on curved sections. Use Types L-852C and 852D for Category III applications.
12.11.2.6. Lamps. Use lamps recommended by the manufacturer. Different manufacturers may meet the requirement using different lamps. In the interest of energy conservation, lower wattage lamps are preferred.

Figure 12.19. FAA L-852, In Pavement, Bi-Directional, Uni-Directional.

LIGHT: IN PAVEMENT, BI-DIRECTIONAL OR UNI-DIRECTIONAL, FAA AC 150/5345-46 TYPE L-852A,B,C, OR D, AS DETERMINED FOR NARROW-BEAM, WIDE-BEAM, OR CATEGORY III.

LAMP: 6.6A, WATTS AND TYPE AS DETERMINED BY THE MANUFACTURER.

UNI-DIRECTIONAL LIGHTS ARE PROVIDED BY BLANKING OUT ONE BEAM.



12.11.3. Taxiway Guidance Signs. Reference paragraph 5.6. Use signs meeting the requirements of FAA AC 150/5345-44, Type L-858Y for informational signs and Type L 858R for mandatory signs. The style and the class of sign are dictated by the power source and the operational climate. (See figures 12.20 and 12.21).

Figure 12.20. FAA L-858Y, Sign, Taxiway, Informational.

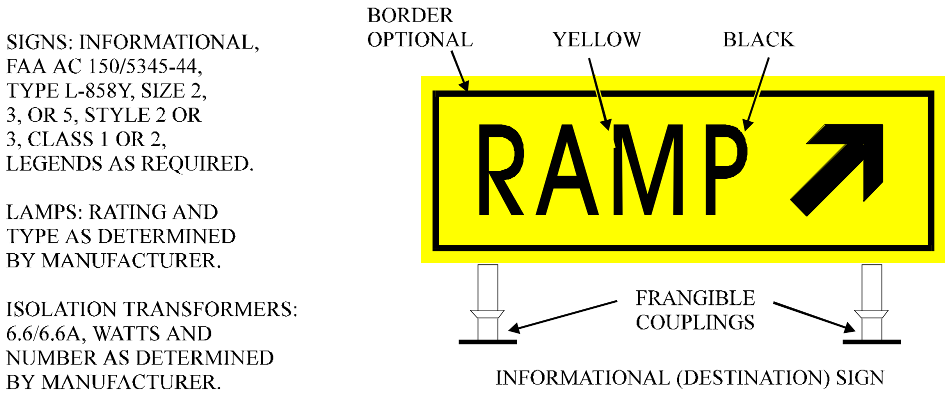
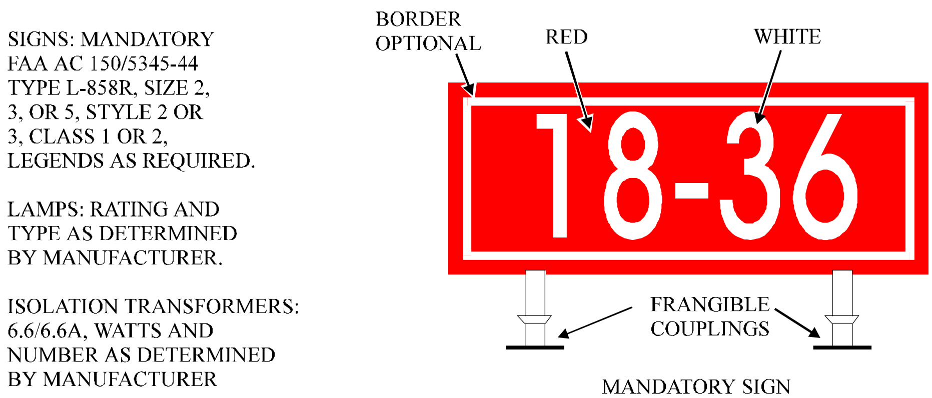
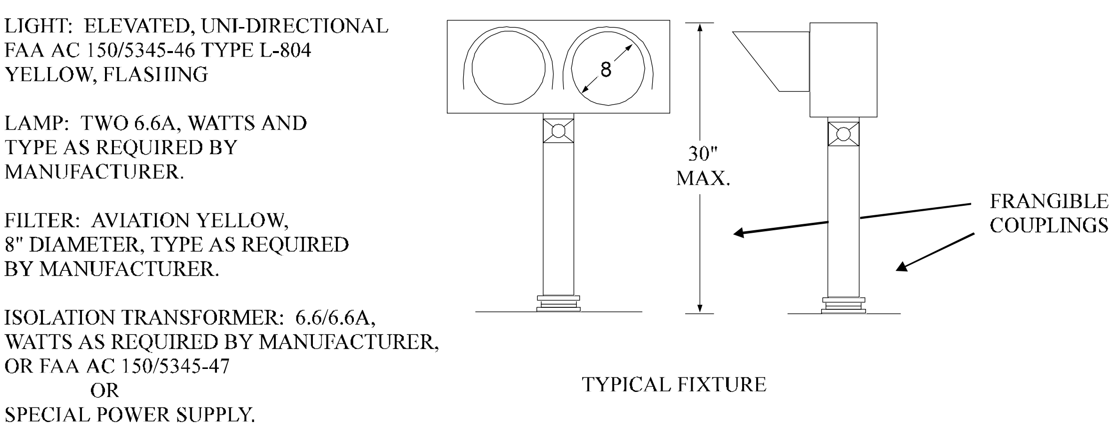


Figure 12.21. FAA L-858R, Sign, Taxiway, Mandatory.



12.11.4. Hold Position Lights (Wig Wag) (Runway Guard Lights). Reference paragraph 5.5. Use FAA-L-804 elevated fixture. (See figure 12.22).

Figure 12.22. FAA L-804, Elevated, Uni-Directional Fixture (Wig Wag) (Runway Guard Lights).

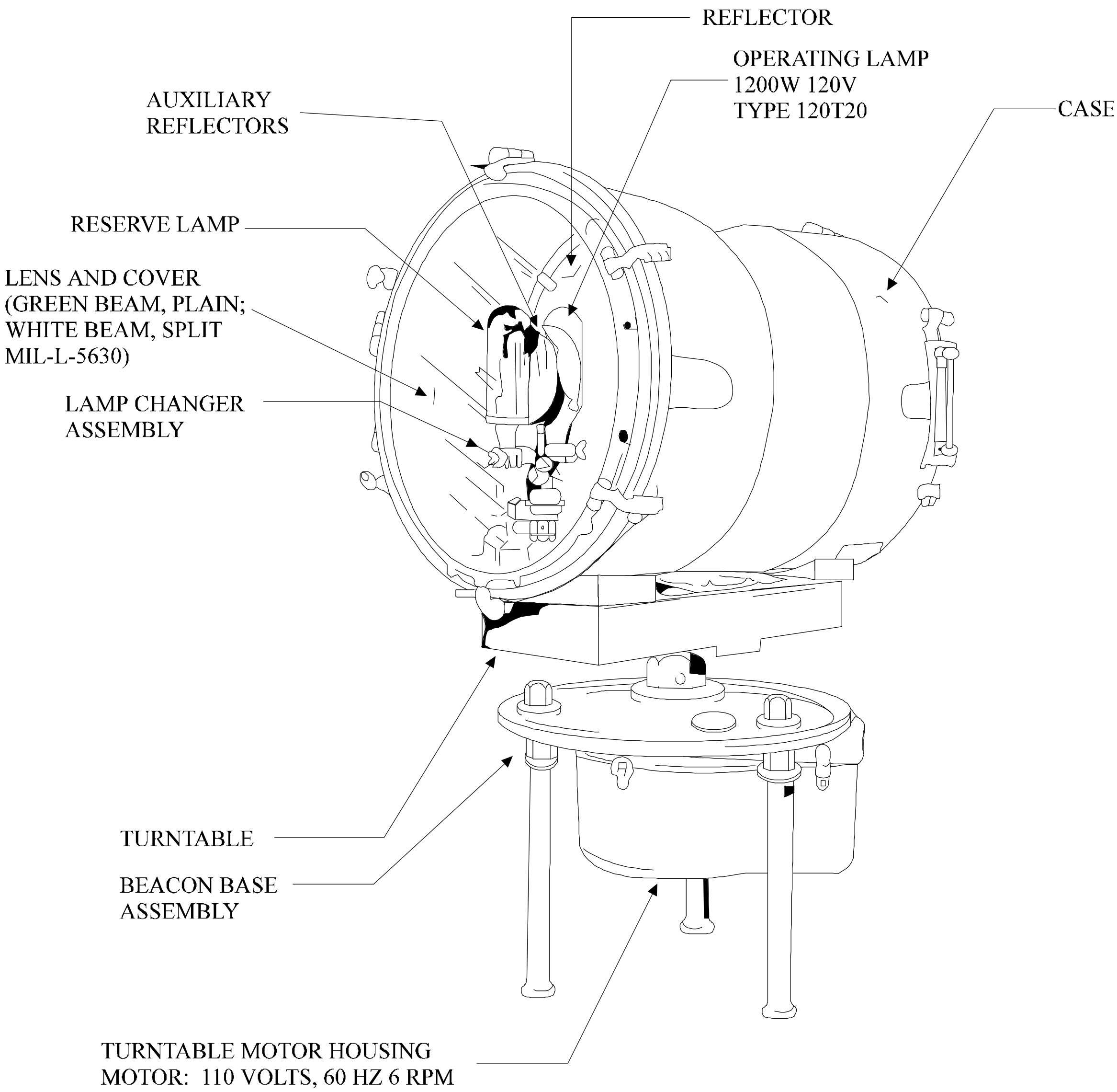


12.12. Miscellaneous Lighting Systems:

12.12.1. Airfield Beacons. Reference paragraph 9.1.

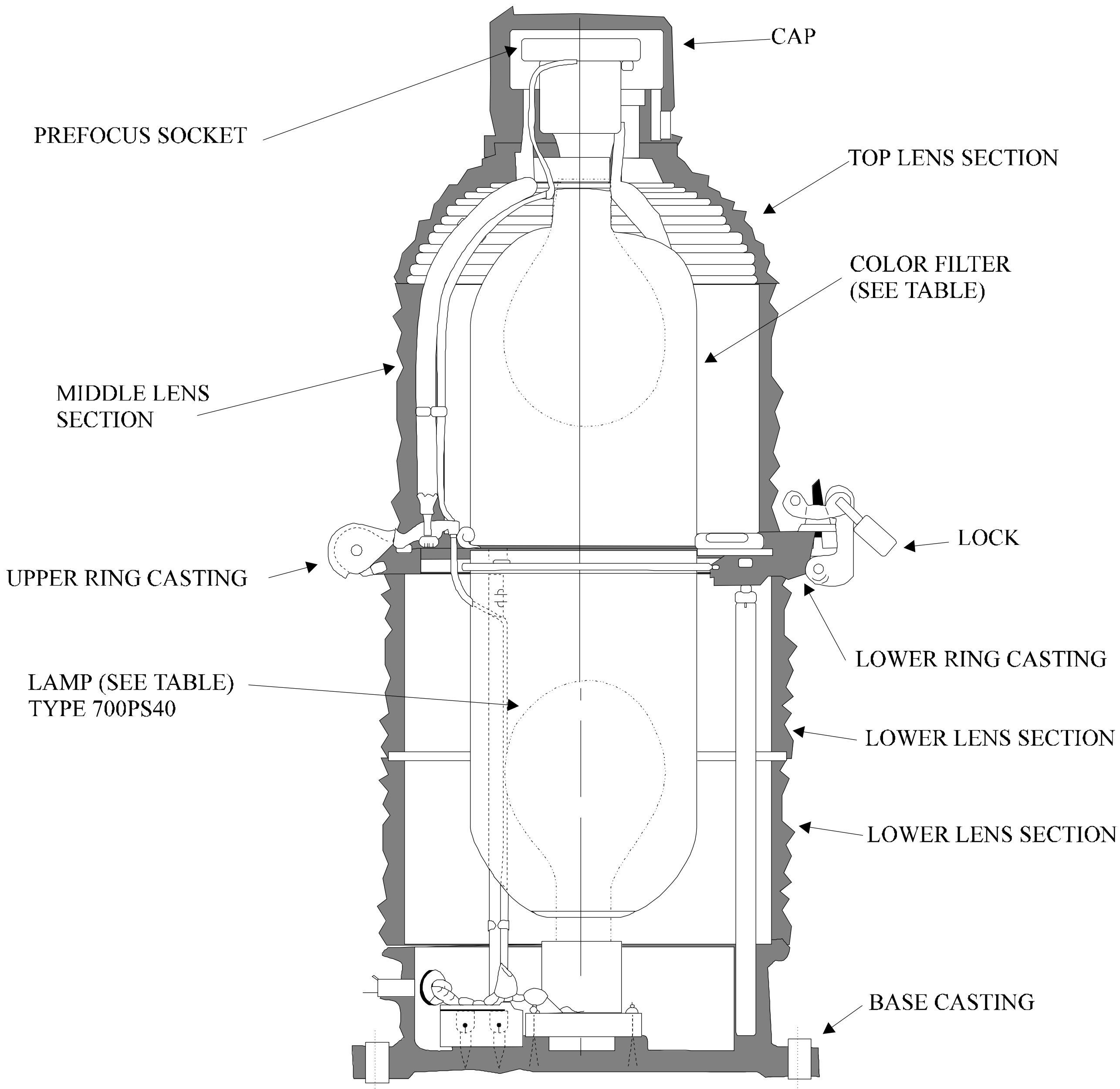
12.12.1.1. Station Rotating Beacon. Use equipment meeting MIL-L-7157. (See figure 12.23). Use equipment meeting FAA AC 150/5345-12, Type L-802A only if provided with a double peak in the white portion of the sequence.

Figure 12.23. MIL-L-7158, Airfield Beacon, Rotating.



12.12.2. Identification Beacon. Use coded beacon equipment meeting MIL-L-6273. See figure 12.24 and MIL-K-6046, or meeting FAA AC 150/5345-12, Type L-803A.

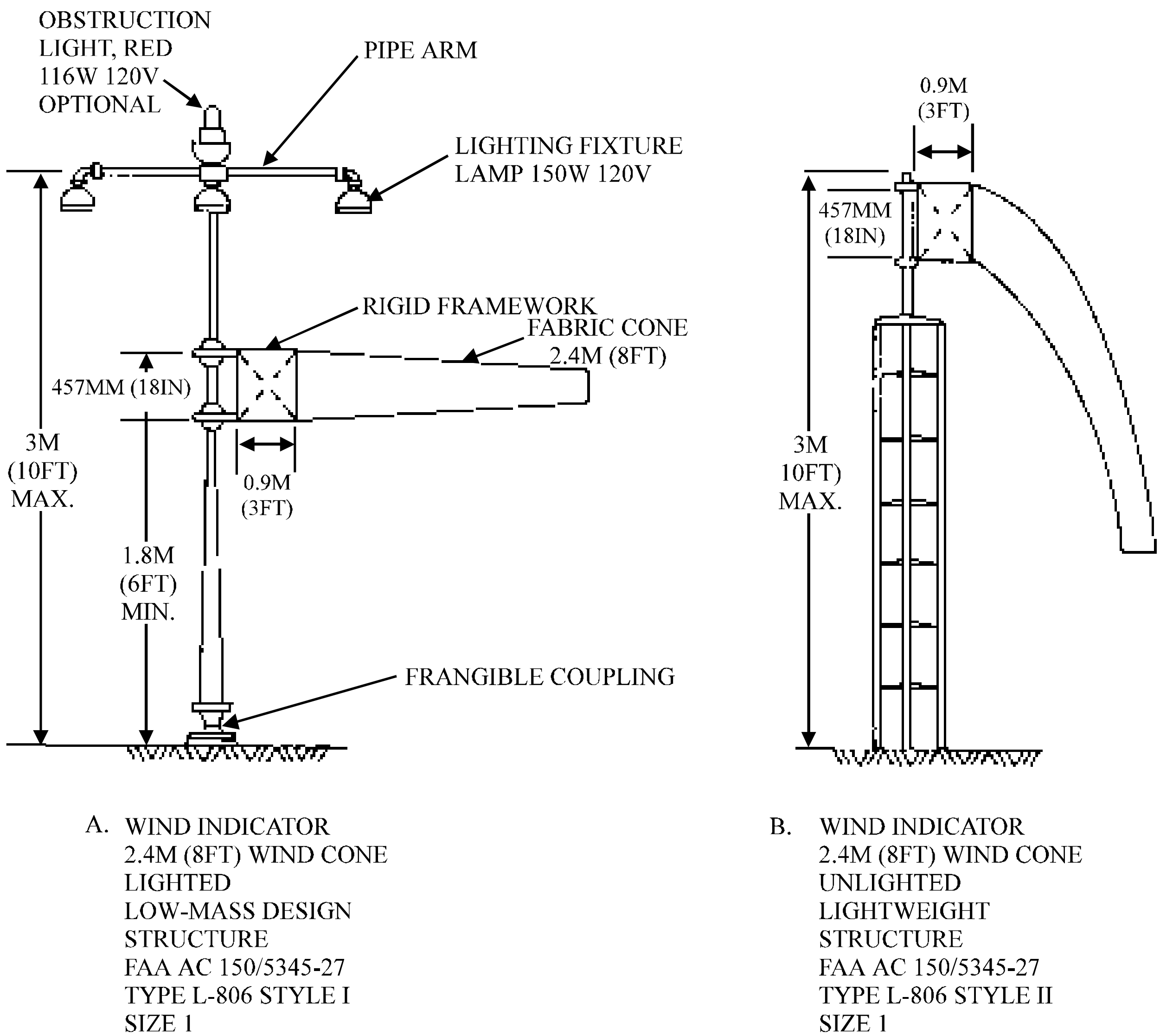
Figure 12.24. MIL-L-6273, G1, Beacon, Code, Flashing.



G-1 BEACON - SPECIFICATION MIL-L-6273					
LAMP			FILTER, MIL-L-6273		
NO. REQD.	WATTS	VOLTS	COLOR	NO. REQD.	USE
2	700	120	RED GREEN	2 2	AS OBSTRUCTION BEACON AS IDENTIFICATION OR CODE BEACON

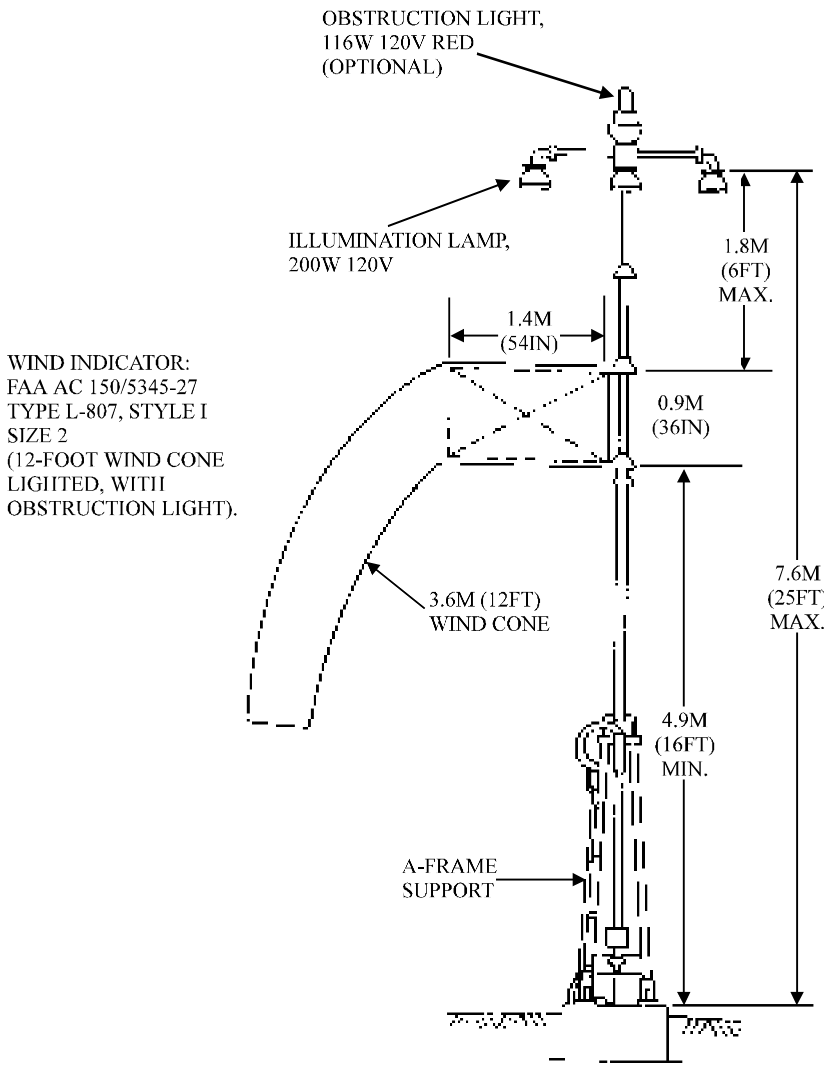
12.12.3. Lighted Wind Indicators (Cones). Reference paragraph 9.2. Use equipment meeting FAA AC 150/5345-42, Type L-806, size I or Type L-807 size 2. (See figures 12.25 and 12.26).

Figure 12.25. FAA L-806, Windcone, 8 Foot.



(DIMENSIONS ARE FOR REFERENCE ONLY)

Figure 12.26. FAA L-807, Windcone, 12 Foot.



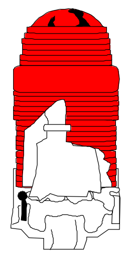
12.12.4. Electrical Equipment. The equipment used depends on the power source. If required, use isolation transformers meeting FAA AC 150/5345-47, installed in bases meeting FAA AC 150/5345-42, Type L-867.

12.13. Obstruction Lighting Equipment. Reference paragraph 6.1.

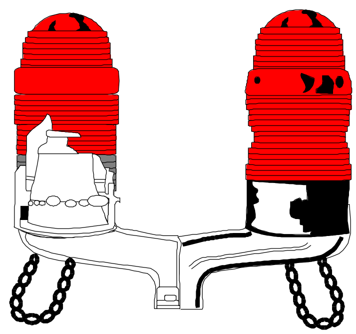
12.13.1. Flashing Beacons. Use flashing beacon equipment in red light meeting MIL-L-6273 (see figure 12.24) or FAA AC 150/5345-43, Type L-864.

12.13.2. Steady Burning Lights. Use steady burning red lights meeting MIL-L-7830 or FAA AC 150/5345-43, Type L-810. These lights are supplied in single or duplex fixtures. (See figure 12.27).

Figure 12.27. FAA L-810, Obstruction Light, Red, Single, or Double Globe, Steady Burning.



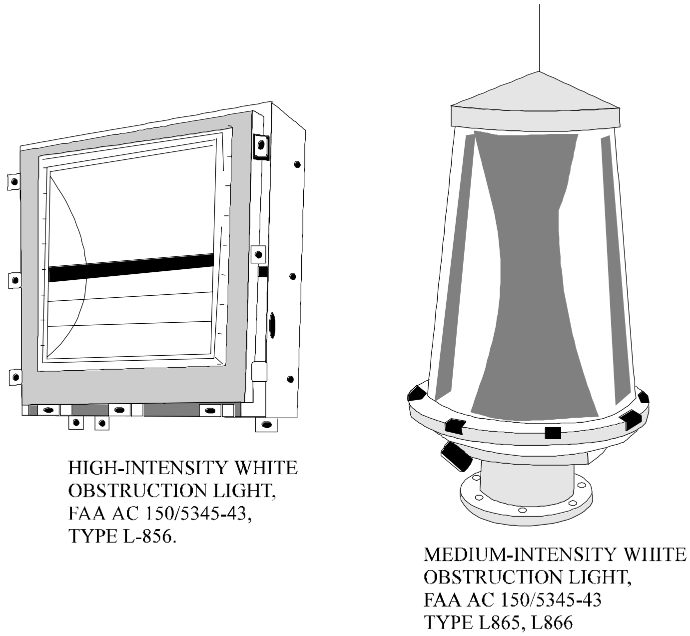
SINGLE STEADY-BURNING LIGHTS,
FAA-AC 150/5345-43 TYPE L-810,
116W 120V TYPE 116A21/TS, OR
125W 120V TYPE 125A21/P LAMP.



DOUBLE STEADY-BURNING LIGHTS
FAA AC 150/5345-43 TYPE L-810,
116W 120V TYPE 116A21/TS, OR
125W 120V TYPE 125A21/P LAMP

12.13.3. High Intensity Day Marking Light. Use equipment meeting FAA AC 150/5345-43, Type L-856. (See figure 12.28).

Figure 12.28. FAA L-856, 857, 865, 866, Obstruction Lights, Flashing, High or Medium Intensity.



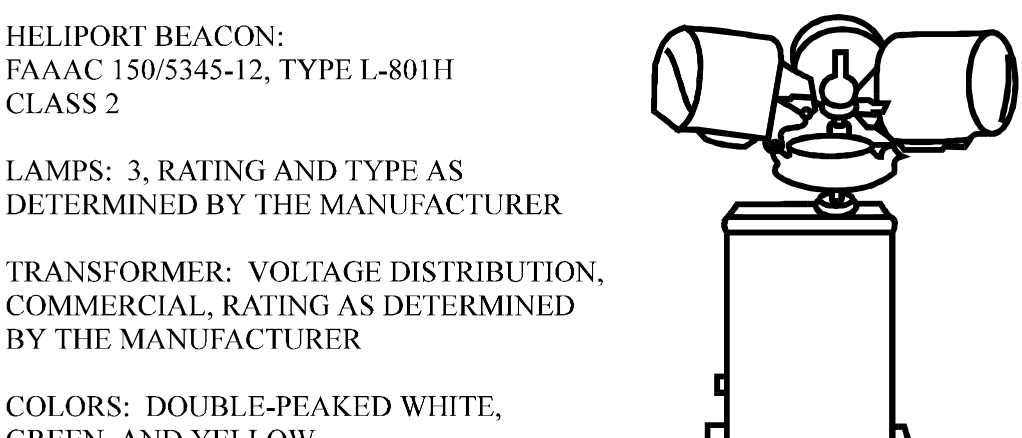
12.14. Helipad Lighting Equipment. Reference paragraph 7.1.

12.14.1. Elevated Perimeter, Landing Direction and Approach Direction Lights. Use fixtures meeting FAA AC 150/5345-46, Type L-861. (See figure 12.12). Use yellow filters except in approach direction lights which are white.

12.14.2. In Pavement Perimeter, Landing Direction and Approach Direction Lights. Use fixtures meeting FAA AC 150/5345-46, Type L-852E. (See figure 12.18). Use yellow filters except in approach direction lights which are white.

12.14.3. Heliport Beacons. Use beacon equipment meeting FAA AC 150/5345-12, Type L-801H. (See figure 12.29).

Figure 12.29. FAA L-801H, Beacon, Rotating, Helipad.



12.14.4. Helipad Floodlighting. No specific equipment has been identified to meet the standard.

12.14.5. Helipad Wind Indicators (Cones). Use indicator meeting FAA AC 150/5345-27, type L-806. (See figure 12.25).
12.14.6. Helipad Approach Path Indicator (CHAPI). This system is a modified PAPI system with a green glide path indicator added (usually 2 degrees) use equipment meeting FAA AC 150/5345-27.

12.15. Specification Availability. Various FAA Specifications are cited in this manual in the text and figures. The following is a title list of those that are cited.
12.15.1. FAA Advisory Circulars. The FAA has available an Advisory Circular Checklist AC OO-2.X, that lists all of the documents, and how to obtain them. The FAA may be contacted at 1-800-FAA-SURE, or (202) 267-9532, Fax, 202-512-2250. The following FAA advisory circulars, shown in table 12.1, may be obtained from the US Department of Transportation, Distribution Requirements Section, M-483.1, Washington, DC 20590. Request latest edition.

Table 12.1. List of FAA Advisory Circulars.

DOC. NO.	TITLE
AC 70/7460-1	Obstruction Marking and Lighting
AC 150/5340-24	Runway and Taxiway Edge Light Systems
AC 150/5345-3	Specification for L-821 Panels for Remote Control of Airport Lighting.
AC 150/5345-5	Circuit Selector Switch.
AC 150/5345-7	Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits.
AC 150/5345-10	Specification for L-828 Constant Current Regulators Regulator Monitors.
AC 150/5345-12	Specification for Airport and Heliport Beacon.
AC 150/5345-13	Specification for L-841 Auxiliary Relay Cabinet Assembly for Pilot Control of Airport Lighting Circuits.
AC 150/5345-26	Specification for L-823 Plug and Receptacle, Cable Connectors.
AC 150/5345-27	Specification for Wind Cone Assemblies.
AC 150/5345-28	Precision Approach Path Indicators (PAPI) Systems.
AC 150/5345-42	FAA Specification L-857, Airport Light Bases, Transformer Houses, and Junction Boxes and accessories.
AC 150/5345-43	Specification for Obstruction Lighting Equipment.
AC 150/5345-44	Specification for Taxiway and Runway Signs.
AC 150/5345-45	Lightweight Approach Light Structure.
AC 150/5345-46	Specification for Runway and Taxiway Light Fixture.
AC 150/5345-47	Isolation Transformers for Airport Lighting Systems.
AC 150/5345-50	Specification for Portable Runway Lights.
AC 150/5345-51	Specification for Discharge Type Flasher Equipment.

12.15.2. Standards, Specifications, and Drawings. The following standards, specifications, and drawings, shown in table 12.2, may be obtained from the Federal Aviation Administration, Program Engineering and Maintenance Service, Washington, DC 20591.

Table 12.2. List of Standards, Specifications, and Drawings.

DOC. NO.	TITLE
FAA-E-910G	Structural Steel.
FAA-E-982G	PAR 56 Lamp Holder.
FAA-E-1315A	Light Base and Transformer Housing.
FAA-E-2159B	Runway End Identifier Lighting System (REIL).
FAA-E-2325D	Medium Intensity Approach Light System with Alignment Indicator Lights.
FAA-E-2491-B	Approach Light, Semi-flush, Steady Burning.
FAA-E-2628B	Sequenced Flashing Lighting System Elevated and Semi-flush with Dimming and Monitoring.
FAA-E-2651	Omni Directional Approach Lighting System (ODALS).
FAA-E-2689A	Dual Mode High Intensity Approach Lighting System (ALSF-2/SSALR).
FAA-E-2690	Isolation Transformer for Approach Lighting System (1500 watt).
FAA-E-2702	Low Impact Resistant Structures.
FAA-E-2756	Four Box PAPI.
FAA Drawing C-6046A	Frangible Coupling Type 1 and Type 1A, Details.
FAA Drawing D-6076	ALSF-2 Approach Lighting System 6’-0” to 128’-0” Low Impact Resistant (LIR) Structures.
FAA Drawing D-6155	ALSF-2, 6’ to 128’ and MALS, 40’ to 128’ LIR Structures.

Chapter 13

AIR FACILITY EQUIPMENT ACCEPTANCE TESTS

13.1. Contractual Acceptance Tests. Before placing a new system into service it shall be tested and inspected to ensure the system is operating properly and has been constructed as designed. A commissioning flight inspection, conducted by the government, shall also be performed on all light systems covered by AFMAN 11-225. Responsibility for any deficiencies found shall be determined and corrective action completed before releasing the construction contractor. The other tests in this chapter apply to the contractual acceptance tests of new installations. Include the applicable test procedures in the contract specifications. If the installation is not accomplished by contract, the tests shall be performed before making the system operational.
13.1.1. Caution in Testing High Voltage Equipment. Most airfield lighting circuits and power supply equipment operate at high voltages. The tests shall be performed only by qualified personnel who are familiar with high voltage electrical equipment and the safety precautions which must be observed.

13.2. Guarantee Period. Each installation contract shall include a guarantee or warranty clause. It shall specify a period of at least one year, after acceptance, during which the installation contractor is responsible for repairing and replacing, without charge, all cable or equipment failures resulting from poor work performance or defective materials and equipment. Damp or dirty cable connectors and cable damage due to faulty installation practices often cause a system failure several months after installation.

13.3. Visual Examination. Thorough visual inspections are the most important of all inspection and test procedures. Visual inspections shall be made frequently during installation, at completion of installation, and before energizing the circuits. A careful visual inspection will reveal defects that should be corrected before acceptance tests and energizing. Serious damage may occur if defects are subjected to electrical tests or energizing. Visual inspections will include:

- Correctness of external connections.
- Good workmanship.
- Cleanliness.
- Safety hazards.
- Specific requirements listed below for individual items. All equipment manufactured under specifications pass strict factory tests before shipment, but it must be inspected for shipping damage immediately upon receipt.

13.4. Cable, Connector, and Isolation Transformer Inspection. The primary and secondary cable leads of the transformers are supplied with factory-installed molded connectors. Visual inspection of these items during installation is very important. Minor cuts, bruises, or mishandling may result in a progressive deterioration which will eventually cause complete failure, but not until some time after acceptance tests. During installation, the following items shall be inspected.
13.4.1. Connectors. The mating surfaces of molded connectors are to be clean and dry when plugged together. If clean and dry inside, these high voltage connectors, with taping, form a connection equal or superior to a conventional high voltage splice. Conversely, if they are wet or dirty inside, no amount of taping can produce a satisfactory connection. Two or three turns of tape, or heat shrink tubing, should be used to hold the connector together and keep the parting line clean. Cleanliness of mating surfaces can be ensured by keeping the factory-installed caps in place until the final connection is made. The

mating surfaces of uncapped connectors should not be laid down, touched, or breathed upon. If a connection must be broken the connectors should be immediately capped.

13.4.1.1. The connectors are to be completely plugged together. After initial plugging, trapped air pressure may partially separate the plug and receptacle. If this happens, wait a few seconds and push them together again. Two or three turns of tape should be used to hold them in place.

13.4.2. Cables**:**

13.4.2.1. The cables are not to be cut by shovels, nicked, crushed by vehicle wheels, bruised by rocks, or damaged in any way during handling and installation.

13.4.2.2. The cables are to be buried to the specified depth below finished grade, and all other detailed requirements of the installation specification have been met.

13.4.2.3. The cables should not directly cross each other and are separated by the specified distance.

13.4.2.4. Screened material should be placed under and over the cables, and rocks or pebbles should not contact the cables.

13.4.2.5. The cables are not to be bent sharply where they enter (or leave) a conduit, and should be supported properly by tamped ground so future settling will not cause sharp bends.

13.5. Cable Electrical Tests. Cable directly buried in earth (that is, not in duct or conduit) shall be tested before and after the trench is back filled. Each underground circuit shall be tested as follows:

13.5.1. Continuity ohmmeter or equivalent continuity test on each series circuit. The circuit should then be checked with a megger test set, to make sure it is free of grounds. Any faults indicated by these tests should be located and repaired before proceeding with high voltage tests.

13.5.2. High voltage insulation resistance test on each series and multiple underground circuit to determine complete freedom from grounds. Whenever possible, these tests shall be performed when the ground is thoroughly wet. Circuits which pass insulation resistance tests during dry weather may fail after a heavy rain.

13.5.2.1. The test procedure follows for each circuit:

1. Disconnect both leads from the regulator output terminals. Support both leads so there are air gaps of several inches between bare conductors and ground. Make sure the cable sheath is clean and dry for a distance of at least 300 millimeters (1 foot) from the end of the cable. Also make sure exposed insulation at the end of the cable is clean and dry.
2. Test each circuit immediately after installation according to “First Test for New Circuits.” Test any circuit installed for 60 days or more, even if it has not been operated, according to “Succeeding Tests and Old Circuits.” See table 13.1.
3. The maximum acceptable leakage current, in microamperes, should not exceed the values in paragraph 13.5.2.4.
4. When additions are made to old circuits, test only the new sections according to “First Test on New Circuits.” Test the complete circuit at the reduced voltages to ensure reliable operation. See table 13.1.
5. Connect both conductors, and apply the test voltage shown for 5 minutes between conductors and ground.

Table 13.1. Cable/Circuit Test Procedures.

	First Test on New Circuit	Succeeding Old Circuit
Complete Approach System (5,000V leads, 500 and 300W transformers)	9,000V	5,000V
Touchdown Zone and Center-line Light Circuits (5,000V leads, 200W transformers)	9,000V	5,000V
High Intensity Runway Edge Light Circuits, (5,000V leads, 500 and 200W transformers)	9,000V	5,000V
Medium Intensity Runway and Taxiway Circuits (5,000V leads and 30/45W transformers)	6,000V	3,000V
600 Volt Circuits	1,800V	600V

13.5.2.2. The above tests must be performed with a suitable high voltage tester which has a steady, filtered output voltage. The high voltage tester must have an accurate voltmeter and microammeter for reading the voltage applied to the circuit and the insulation leakage current.

13.5.2.3. All high voltage tests on airfield lighting circuits must be carefully supervised by qualified government personnel to ensure that excessive voltages are not applied to circuits.

13.5.2.4. During the last minute of the above tests, the insulation leakage current in microamperes for each complete circuit must not exceed the following value calculated for each circuit:

- Allow zero microamperes for each 30/45, 100, 200, 300 and 500W series transformer hi-potted at 5000 volts or below.
- Allow one microamperes for each 1,000 feet of cable hi-potted at 5000 volts or below. This value includes allowances for the normal number of connectors and splices.
- Using a 1000 volt DC megger, each circuit must measure above 50 megohms to be satisfactory.

13.5.2.5. If the leakage current exceeds the value calculated as outlined above, the circuit must be sectionalized and the above test repeated for each section. Defective components must be located and repaired or replaced until the entire circuit passes the test.

13.5.2.6. Make sure the test voltage specified in paragraph 13.5.2.1 is actually applied to a circuit in the final acceptance test. The voltage should be adjusted so the voltmeter reads the desired value before the leakage current is read. If there is a difficulty in obtaining the desired voltage, either the circuit being tested or the test set is defective and should be corrected before the test is continued.

13.5.2.7. On new circuits, a megger test check should be made immediately after the circuit has passed the high voltage tests. This megger reading then can be used by maintenance personnel for a comparison with further readings to determine the circuit conditions. Ambient temperature and weather conditions should be recorded at the time of test.

13.6. Constant Current Regulator Inspection. Each constant current regulator shall be inspected to ensure that porcelain bushings are not cracked, no shipping damage has occurred, connections are correct, switches and relays operate freely and are not tied or blocked, fuses (if required) are correct, and the oil level of oil-filled regulators is correct. Only relay panel covers must be removed for this inspection; the main tank of oil-filled regulators need not be opened. Information on the regulator instruction plate must be followed. All covers must be cleaned and tightly replaced after inspection and tests are completed.

13.7. Regulator Electrical Tests. The supply voltage and input tap shall be checked to see that they correspond:

13.7.1. With the load disconnected, energize the regulator once and see if the open-circuit protector de-energizes the regulator within 2 or 3 seconds.

13.7.1.1. Connect the load circuit (after it has been tested for opens and grounds as specified in paragraph 13.5 and inspected to ensure all fixtures are properly lamped).

13.7.1.2. Using a voltmeter and an ammeter of not more than 11 percent deviation from full-scale deflection, measure input voltage and output current simultaneously on all brightness taps.

13.7.1.3. Use a recording voltmeter or take readings during both day and night at enough intervals to obtain an average supply voltage.

13.7.1.4. If the regulator has input voltage taps, select the tap which most nearly corresponds to the average supply voltage. The output current on each brightness tap should be within 12 percent of the nameplate values after any necessary supply voltage correction is made.

13.7.2. In all current regulators with input voltage taps, the output current will vary in proportion to input voltage changes. If a supply voltage of 235 volts is applied to the 230 volt tap, the output current values should be 2 percent above the nameplate values.

13.7.3. For regulators which have automatic supply voltage correction instead of input taps, the output current does not change as the supply voltage varies.

13.7.3.1. If the output current on tap 5 deviates from the nameplate value by more than 2 percent (and the regulator is not overloaded), the internal adjustment must be checked, as described on the regulator instruction plate. Since the adjustment may be delicate, a deviation of +/- 5 percent may be allowed on taps 1 to 4 before attempting to readjust the regulator.

13.7.3.2. A check must also be made to see whether the adjustment had been changed purposely for an unusual local operational requirement.

13.7.4. The following tests are not mandatory, but will help locate the trouble if the above test indicates improper operation:

13.7.4.1. Disconnect the load, short-circuit the output terminals through an ammeter, and measure the output current. If measured values are equal to or slightly higher than nameplate values, the regulator is operating satisfactorily. Check the load circuit for faults.

13.7.4.2. Connect load cables (after the circuit has been tested for opens and grounds, as specified in paragraph 13.5, and inspected to ensure all fixtures are properly lamped) and measure output current and output voltage simultaneously with the regulator operating on the highest brightness tap. The significance of the readings is as follows:

- Satisfactory operation is indicated by correct output current and an output voltage which is slightly higher than the estimated load voltage and does not exceed the rated output voltage. The load voltage may be estimated by multiplying the transformer primary voltage at rated load (watts divided by primary current) by the number of transformers connected in series in the load circuit.
- A correct output current, with an output voltage appreciably less than the estimated load voltage, indicates complete or partial shorting of the load.
- A correct output current, with an output voltage exceeding the rated load output voltage, indicates an overload.
- A reduced output current, with an output voltage exceeding the rated load output voltage, indicates an overload, possibly caused by a poor connection in the load circuit. The regulator should be de-energized immediately to prevent damage.
- A reduced output current, with an output voltage not exceeding the rated output voltage, indicates a faulty regulator or reduced supply voltage.

- A zero output current, with excessive output voltage, indicates an open in the load circuit and failure of the open-circuit protector in the regulator. The regulator should be de-energized immediately to prevent serious damage.

13.8. Lighting Fixture Inspection. An inspection shall be made to determine that the color, quantity, and locations of lights meet the installation drawings. Each light shall be inspected to determine that it operates, is properly leveled and aimed, glass is not broken or cracked, and correct lamps are installed, all according to the technical orders and manufacturer's instructions.

13.9. System Miscellaneous Components Inspection. Components such as control panels, relay cabinets, panelboards, etc., shall be visually inspected for damage, correct connections, proper fuse and circuit breaker ratings, and compliance with the installation drawings.

13.10. System Operation. After components and circuits have been inspected and tested, as specified in the preceding paragraphs, the entire system shall be tested as follows:
13.10.1. Procedures:
13.10.1.1. Operate each switch of the airport lighting and taxiway panel in the control tower so each switch position is reached at least twice. During this process, observe all lights and vault equipment to determine that each switch properly controls the corresponding circuit.
13.10.1.2. Repeat the above test for the panel in the alternate control station (vault) and then repeat it again, using the local control switches on the regulators.
13.10.1.3. Operate each lighting circuit continuously at maximum brightness for at least 6 hours. Make a visual inspection at the beginning and end of this test to determine that the correct number of lights are operating at full brightness. Dimming of some or all of the lights in a circuit is an indications of grounded cables. In addition, measure the lamp terminal voltage on at least one light in each multiple circuit to determine that it is within +5 percent of the rated lamp voltage marked on each lamp.

13.11. Additional Guidance. Additional guidance on acceptance testing is in the FAA Advisory Circulars listed in Chapters 11 and 12.

WILLIAM P. HALLIN, Lt General USAF
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Attachment 1

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND TERMS

Abbreviations and Acronyms

AGM	Arresting Gear Marker
AIR STD	Air Standard
ALS	Approach Landing System
ALSF	Approach Lighting System with Sequence Flashing Lights
ALSF-1	Approach Lighting System with Sequence Flashing Lights for CAT I
ALSF-2	Approach Lighting System with Sequence Flashing Lights for CAT II or CAT III
ASCC	Air Standardization Coordinating Committee
ASR	Airport Surveillance Radar
CAT I, II, & III	See definitions above
CD	Candela
CHAPI	Chase Helicopter Approach Path Indicator
FAA	Federal Aviation Administration
Foot Candle	One Lumen per square foot (Use 10 lux) (10.8 is more exact)
GCA	Ground Controlled Approach
GPS	Global Positioning System
HAT	Height Above Threshold
HIRL	High Intensity Runway Edge Lights
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
LDIN	Lead-in Lights
Lux	One lumen per square meter (Use 1/10 foot candle) (0.0929 is more exact)
MALSR	Medium Intensity Approach Light System with Runway Alignment Indicators
MAS	Military Agency for Standardization
MLS	Microwave Landing System
MIRL	Medium Intensity Runway Edge Lights
NATO	North Atlantic Treaty Organization
PAPI	Precision Approach Path Indicator
PAR	Precision Approach Radar
RAIL	Runway Alignment Indicator Lights
RCL	Runway Centerline Lights
RDM	Runway Distance Markers
REIL	Runway End Identifier Lights
RGL	Runway Guard Lights
RRP	Runway Reference Point
RVR	Runway Visual Range
SALS	Short Approach Light System
SFL	Sequenced Flashing Lights
SSALR	Simplified Short Approach Light System with Runway Alignment Indicator Lights
STANAG	Standardization Agreement

TACAN	Tactical Air Navigation
TCH	Threshold Crossing Height
TDZL	Touchdown Zone Lights
VFR	Visual Flight Rules
VLA	Visual Landing Aids
VORTAC	Very High Frequency Omni-directional Range with TACAN

Terms

Approach Lighting System (ALS) Centerline -- The ALS centerline is the extended centerline of the runway being served.

Approach Light Plane -- An imaginary plane that passes through the beam centers of the lights in the system. The plane is rectangular, centered on the ALS centerline, starting at the landing threshold and extending 60 meters (200 feet) beyond the last light at the approach end of system. The plane may have irregularities. The width varies according to the lighting system.

Basic Runway -- A runway used for operation under visual flight rules (VFR).

Decision Height -- The height above the highest elevation in the touchdown zone, specified for a glide slope approach at which a missed approach procedure must be initiated if the required reference has not been established.

Displaced Threshold Area -- An area of full strength pavement on the approach slope of the threshold intended for use during takeoff or during rollout after landing from the opposite direction.

Flush Fixture -- A fixture installed so that no part of the assembly is above the surrounding surface.

Frangible Support -- A support for elevated fixtures or other devices composed of a supporting element with a fracture mechanism at its base. It is designed to present a minimum of mass and to break at the base when impacted. Normally used when the mounting height is 2 meters (6 feet) or less above the mounting surface.

Ground Controlled Approach (GCA) -- An instrument approach predicated on ground based electronic equipment (Airport Surveillance Radar) (ASR) or Precision Approach Radar (PAR) and directed by ground based personnel communicating with the approaching aircraft.

In Pavement Fixture – See Flush/Semi-flush Fixture.

Instrument Runway -- A Runway served by non-visual aids giving directional guidance adequate for a straight in approach. It may be further classified as:

Non-precision Instrument Approach Runway -- A runway served by a non-precision aid (such as TACAN or Very High Frequency omni-directional Range with TACAN[VORTAC]), providing directional guidance adequate for a straight-in approach.

Precision Approach Runway, Category I -- A runway served by an Instrument Landing System (ILS), Microwave Landing System (MLS) or precision Approach Radar (PAR) and visual aids intend for operations down to 60 meters (200 feet) decision height, and down to a runway visual range (RVR) on the order of 720 meters (2,400 feet). This criteria also applies to visual lighting aids supporting US Air Force precision approach radar approaches down to a decision height of 30 meters (100 feet) and an RVR on the order of 360 meters (1,200 feet).

Precision Approach Runway, Category II -- A runway served by ILS or MLS and visual aids intended for operations down to 30 meters (100 feet) decision height and down to an RVR on the order of 360 meters (1,200 feet).

Precision Approach Runway, Category III -- A runway served by ILS or MLS (no decision height being applicable) and:

- Category IIIa: By visual aids intended for operations down to an RVR on the order of 210 meters (700 feet).
- Category IIIb: By visual aids intended for operations down to an RVR on the order of 45 meters (150 feet).
- Category IIIc: Intended for operations without reliance on external visual reference. (The RVR is 0).

Landing Threshold -- The beginning of that portion of a runway useable for landing.

Light Bar -- A set of lights arranged in a row perpendicular to the light system centerline. It is also known as a barrette.

Low-Impact Resistant Support -- A support for elevated fixtures or other devices designed to present a minimum mass and to break with a minimum resistance when impacted. Normally used for supporting lights between 2 meters and 12 meters (6 feet and 40 feet) above the mounting surface.

Negative Slope -- A slope of the approach light plane downward and outward from the landing threshold.

Overrun -- An area on the approach side of the runway threshold which is stabilized or paved but is not intended for normal operational use. It serves as a safety area for aircraft which overrun the end of the runway or touch down short of the threshold.

Positive Slope -- A slope of the approach light plane upward and outward from the landing threshold.

Rigid Support -- A support for elevated lights or other devices which has been designed to support the lights under all foreseeable weather conditions without regard for impact resistance. Do not use these supports in new construction for systems in safety clearance zones or where there is present danger of impact by aircraft.

Runway Centerline -- A line halfway between the edges of the surface designated for normal aircraft landing and takeoff operations.

Runway End -- The longitudinal limit of usable runway opposite the runway threshold. It often, but not always, coincides with the threshold of the opposite direction runway surface.

Runway Visual Range (RVR) -- The maximum distance in the direction of take-off or landing from which the runway (or the specified lights or markers delineating it) can be seen from a position above a specified point on the runway centerline and at a height corresponding to the average eye-level of pilots at touchdown.

Semi-flush Fixture -- A fixture designed for installation in paved areas which does not extend more than a specified distance above the surrounding paved area and is capable of roll-over by aircraft. The distance is specified in the text for the system using the fixture.

Semi-frangible Support -- A two element support for light fixtures or other devices designed for use in applications where the mounting is over 12 meters (40 feet) above the ground and exceeds the design limits for low impact resistant supports mounted on a rigid support and a means to lower the lights for servicing.

Tow-in – To move the light beam of the fixture toward the runway centerline from either the right or left side of the centerline (usually 2.0degrees or 3.5 degrees). Designate right or left when ordering.