

## TABLE OF CONTENTS

|   |           |
|---|-----------|
| <b>CHAPTER 1. INTRODUCTION.....</b>                                     | <b>1</b>  |
| 1.1. GENERAL.....   | 1         |
| 1.2. SCOPE.....   | 1         |
| 1.3. SAFETY.....  | 1         |
| 1.4. MIXING OF light source TECHNOLOGIES.....                           | 1         |
| <b>CHAPTER 2. RUNWAY AND TAXIWAY EDGE LIGHTING SYSTEMS.....</b>         | <b>3</b>  |
| 2.1. GENERAL.....   | 3         |
| 2.1.1. Selection Criteria.....  | 3         |
| 2.1.2. Runway Edge Light Configurations.....                            | 3         |
| 2.1.3. Stopway Edge Lights.....   | 6         |
| 2.1.4. Taxiway Edge Light Configurations.....                           | 7         |
| 2.1.5. System Design.....   | 9         |
| 2.1.6. Equipment and Materials.....                                     | 12        |
| <b>CHAPTER 3. RUNWAY CENTERLINE AND TOUCHDOWN LIGHTING SYSTEMS.....</b> | <b>14</b> |
| 3.1. INTRODUCTION.....  | 14        |
| 3.2. SELECTION CRITERIA.....  | 14        |
| 3.3. CONFIGURATION.....   | 14        |
| 3.4. DESIGN.....  | 15        |
| 3.5. EQUIPMENT AND MATERIAL.....  | 16        |
| <b>CHAPTER 4. TAXIWAY LIGHTING SYSTEMS.....</b>                         | <b>19</b> |
| 4.1. INTRODUCTION.....  | 19        |
| 4.2. IMPLEMENTATION CRITERIA.....                                       | 19        |
| 4.3. TAXIWAY CENTERLINE.....  | 20        |
| 4.4. RUNWAY GUARD LIGHTS (RGLs).....                                    | 24        |
| 4.5. RUNWAY STOP BAR.....   | 25        |
| 4.6. COMBINATION IN-PAVEMENT STOP BAR AND RGLS.....                     | 26        |
| 4.7. CLEARANCE BAR CONFIGURATION.....                                   | 27        |
| 4.8. DESIGN.....  | 28        |
| 4.9. EQUIPMENT AND MATERIAL.....  | 36        |
| 4.10. INSTALLATION.....   | 37        |
| <b>CHAPTER 5. LAND AND HOLD SHORT LIGHTING SYSTEMS.....</b>             | <b>38</b> |
| 5.1. INTRODUCTION.....  | 38        |
| 5.2. BACKGROUND.....  | 38        |
| 5.3. DEFINITIONS.....   | 38        |
| 5.4. IMPLEMENTATION CRITERIA.....                                       | 38        |
| 5.5. CONFIGURATION.....   | 38        |
| 5.6. DESIGN.....  | 39        |

5.7. EQUIPMENT AND MATERIAL .....41

5.8. INSTALLATION .....42

**CHAPTER 6. AIRFIELD MISCELLANEOUS AIDS.....45**

6.1. AIRPORT ROTATING BEACONS .....45

6.2. SYSTEM DESIGN .....45

6.3. INSTALLATION .....46

6.4. MAINTENANCE .....47

6.5. BEACON TOWERS .....47

6.6. WIND CONES .....48

6.7. OBSTRUCTION LIGHTS .....49

    6.7.1. Location .....49

    6.7.2. Installation .....50

    6.7.3. Maintenance .....50

6.8. EQUIPMENT AND MATERIALS .....51

**CHAPTER 7. ECONOMY APPROACH AIDS.....53**

7.1. INTRODUCTION .....53

7.2. TYPES OF ECONOMY APPROACH LIGHTING AIDS .....53

7.3. SELECTION CONSIDERATIONS .....53

7.4. CONFIGURATIONS .....54

7.5. DESIGN .....56

7.6. EQUIPMENT AND MATERIAL .....66

7.7. INSTALLATION .....67

**CHAPTER 8. RADIO CONTROL EQUIPMENT.....71**

8.1. RADIO CONTROL EQUIPMENT .....71

    8.1.1 Restrictions on Use of Radio Control .....71

    8.1.2 Radio Control Equipment .....71

    8.1.3 Interfacing the Radio Control with the Lighting Systems .....71

    8.1.4 Coordination With FAA .....74

**CHAPTER 9. STANDBY POWER – NON-FAA.....75**

9.1. BACKGROUND .....75

9.2. DEFINITIONS .....75

9.3. FAA POLICY .....75

9.4. ELECTRICAL POWER CONFIGURATIONS .....76

9.5. DESIGN .....77

9.6. EQUIPMENT AND MATERIAL .....78

9.7. INSTALLATION .....80

9.8. INSPECTION .....81

9.9. TESTS .....82

9.10. MAINTENANCE .....82

|   |            |
|---|------------|
| 9.11. ENGINE GENERATOR EQUIPMENT PERFORMANCE REQUIREMENTS. .... | 83         |
| <b>CHAPTER 10. PAVEMENT TYPES. ....</b>                         | <b>85</b>  |
| 10.1. GENERAL.....  | 85         |
| 10.2. NEW PAVEMENT – RIGID (CONCRETE).....                      | 85         |
| 10.3. NEW PAVEMENT – FLEXIBLE (BITUMINOUS). ....                | 87         |
| 10.4. OVERLAY – RIGID. ....                                     | 88         |
| 10.5. OVERLAY - FLEXIBLE. ....                                  | 89         |
| <b>CHAPTER 11. FIXTURE MOUNTING BASES.....</b>                  | <b>91</b>  |
| 11.1. GENERAL.....  | 91         |
| 11.2. L-868 MOUNTING BASES.....                                 | 91         |
| 11.3. DIRECT-MOUNTED (INSET) FIXTURES.....                      | 93         |
| 11.4. FIELD ADJUSTABLE L-868 MOUNTING BASES. ....               | 95         |
| 11.5. INSTALLATION. ....  | 95         |
| <b>CHAPTER 12. EQUIPMENT AND MATERIAL.....</b>                  | <b>99</b>  |
| 12.1. GENERAL.....  | 99         |
| 12.2. LIGHT BASES, TRANSFORMER HOUSINGS AND JUNCTION BOXES..... | 99         |
| 12.3. DUCT AND CONDUIT.....                                     | 99         |
| 12.4. CABLE, CABLE CONNECTORS, PLUGS AND RECEPTACLES. ....      | 100        |
| 12.5. COUNTERPOISE (LIGHTNING PROTECTION SYSTEM).....           | 102        |
| 12.6. LIGHT BASE GROUND. ....                                   | 104        |
| 12.7. LIGHT FIXTURE BONDING. ....                               | 105        |
| 12.8. CONCRETE. ....  | 105        |
| 12.9. STEEL REINFORCEMENT.....                                  | 105        |
| 12.10. ADHESIVE AND SEALANTS. ....                              | 105        |
| 12.11. LOAD-BEARING LIGHTING FIXTURES. ....                     | 105        |
| 12.12. INSPECTION. ....   | 106        |
| 12.13. TESTING.....   | 107        |
| 12.14. AUXILIARY RELAYS.....                                    | 108        |
| 12.15. VAULT.....   | 108        |
| 12.16. MAINTENANCE.....   | 108        |
| <b>CHAPTER 13. POWER DISTRIBUTION AND CONTROL SYSTEMS. ....</b> | <b>111</b> |
| 13.1. INTRODUCTION.....   | 111        |
| 13.2. POWER DISTRIBUTION. ....                                  | 111        |
| 13.3. CONTROL SYSTEMS.....                                      | 112        |
| <b>APPENDIX 1. FIGURES.....</b>                                 | <b>117</b> |
| <b>APPENDIX 2. AIRPORT TECHNICAL ADVISORY.....</b>              | <b>231</b> |

|  |            |
|--|------------|
| <b>APPENDIX 3. TERMS &amp; ACRONYMS.....</b>   | <b>233</b> |
| <b>APPENDIX 4. BIBLIOGRAPHY. ....</b>  | <b>239</b> |
| <b>APPENDIX 5. TYPICAL INSTALLATION DRAWINGS FOR AIRPORT LIGHTING<br/>EQUIPMENT.....</b> | <b>245</b> |
| A5-1. Electrical Notes .....   | 272        |
| <b>APPENDIX 6. APPLICATION NOTES. ....</b>   | <b>281</b> |
| <b>APPENDIX 7. RUNWAY STATUS LIGHT (RWSL) SYSTEM.....</b>                                | <b>293</b> |
| A7-1. Purpose .....  | 293        |
| A7-1.1. System Description.....  | 293        |
| A7-2. Installation.....  | 294        |
| A7-2.1 Runway Entrance Lights (REL) .....  | 294        |
| A7-2.2 REL Light Base.....   | 294        |
| A7-2.3 REL Configurations.....   | 294        |
| A7-2.3.1 Basic (90-degree) Configuration.....  | 294        |
| A7-2.3.2 Angled Configuration.....   | 295        |
| A7-2.3.3 Curved Configuration.....   | 296        |
| A7-2.4 Takeoff Hold Lights (THL).....  | 296        |
| A7-2.4.1 THL Fixtures .....  | 296        |
| A7-2.4.2 THL Mounting Base.....  | 297        |
| A7-2.5 Constant Current Regulator (CCR) Power Supply.....                                | 297        |
| A7-2.6 Isolation Transformer.....  | 297        |
| A7-2.7 Individual Light Controller (ILC).....  | 298        |
| A7-3 RUNWAY INTERSECTION LIGHTS (RIL).....   | 298        |
| A7-3.1 RIL Mounting Base .....   | 298        |
| A7-3.2 RIL General Installation .....  | 298        |
| A7-3.3 RIL Installation on a Runway with No Centerline Lights .....                      | 299        |
| A7-3.4 Overlapping RILs and THLs .....   | 299        |
| <b>A7-4 DESIGN.....</b>  | <b>300</b> |
| A7-4.1 General Guidelines.....   | 300        |
| A7-4.2 Layout.....   | 300        |
| A7-4.3 Overlay Rigid and Flexible Pavements.....   | 300        |
| A7-4.4 Existing Pavements.....   | 300        |
| <b>A7-5 SURFACE MOVEMENT GUIDANCE CONTROL SYSTEM (SMGCS) .....</b>                       | <b>300</b> |
| <b>A7-5.1 EQUIPMENT AND MATERIAL.....</b>  | <b>300</b> |
| A7-5.2 Lighting Vault.....   | 300        |
| <b>A7-6 OPERATIONAL TESTING.....</b>   | <b>300</b> |

**LIST OF FIGURES**

|            |   |     |
|------------|---|-----|
| Figure 1.  | Legend and General Notes. ....  | 118 |
| Figure 2.  | Runway and Threshold Lighting Configuration (LIRL Runways & MIRL Visual Runways). ....  | 119 |
| Figure 3.  | Runway and Threshold Lighting Configuration (HIRL). ....  | 120 |
| Figure 4.  | Runway with Taxiway at End. ....  | 121 |
| Figure 5.  | Runway with Blast Pad (No Traffic). ....  | 122 |
| Figure 6.  | Lighting for Runway with Displaced Threshold. ....  | 123 |
| Figure 7.  | Normal Runway with Taxiway. ....  | 124 |
| Figure 8.  | Lighting for Runway with Displaced Threshold. ....  | 125 |
| Figure 9.  | Lighting for Runway with Displaced Threshold/Usable Pavement. ....  | 126 |
| Figure 10. | Lighting for Runway with Displaced Threshold not Coinciding with Opposite Runway End. ....  | 127 |
| Figure 11. | Lighting for Runway with Stopway. ....  | 128 |
| Figure 12. | Lighting for Runway with Displaced Threshold & Stopway. ....  | 129 |
| Figure 13. | Runway with End Taxiway. ....   | 130 |
| Figure 14. | Lighting for Runway with End Taxiway and Shortened ASDA. ....   | 131 |
| Figure 15. | Lighting for Runway with End Taxiway and Displaced Threshold not Coinciding with Opposite Runway End. ....  | 132 |
| Figure 16. | Typical Straight Taxiway Sections (Less Than 200 Feet (61 m)). ....   | 133 |
| Figure 17. | Spacing of Lights on Curved Taxiway Edges. ....   | 134 |
| Figure 18. | Typical Single Straight Taxiway Edges (More Than 200 Feet (61 m)). ....   | 135 |
| Figure 19. | Typical Single Straight Taxiway Edges (Less Than 200 Feet (61 m)). ....   | 136 |
| Figure 20. | Typical Edge Lighting Configuration. ....   | 137 |
| Figure 21. | Typical Edge Lighting for Portions of Runways Used as Taxiway (When Taxiway Lights Are “On”). ....  | 138 |
| Figure 22. | Typical Edge Lighting for Portions of Runways Used as Taxiway (When Runway Lights Are “On”). ....   | 139 |
| Figure 23. | Light Fixture Wiring. ....  | 140 |
| Figure 24. | Typical Wiring Diagram Utilizing L-828 Step-type Regulator with External Remote Primary Oil Switch. ....  | 141 |
| Figure 25. | Typical Wiring Diagram Utilizing L-828 Step-type Regulator with Internal Control Power and Primary Oil Switch. ....                                     | 142 |
| Figure 26. | Typical Basic 120 Volt AC Remote Control System. ....   | 143 |
| Figure 27. | Alternative 120 Volt AC Remote Control System. ....   | 144 |
| Figure 28. | Typical 120 Volt AC Remote Control System with L-847 Circuit Selector Switch. ....  | 145 |
| Figure 29. | Typical 48 Volt DC Remote Control System with 5-Step Regulator and L-841 Relay Panel. ....  | 146 |
| Figure 30. | Typical 48 Volt DC Remote Control System with 3-Step Regulator and L-841 Relay Panel. ....  | 147 |
| Figure 31. | Curves for Estimating Loads in High Intensity Series Circuits. ....   | 148 |
| Figure 32. | Curves for Estimating Loads in Medium Intensity Series Circuits. ....   | 149 |
| Figure 33. | Runway Centerline Lighting Layout. ....   | 150 |
| Figure 34. | Touchdown Zone Lighting Layout. ....  | 151 |
| Figure 35. | Section Through Non-adjustable Base and Anchor, Base and Conduit System, Rigid Pavement. ....   | 152 |
| Figure 36. | Section Through Non-adjustable Base and Anchor, Base and Conduit System, Flexible Pavement. ....  | 153 |
| Figure 37. | Runway Centerline Light – Shallow Base & Conduit Installation. ....   | 154 |
| Figure 38. | Saw Kerf Wireway Details. ....  | 155 |
| Figure 39. | Saw Kerf Orientation Details – R/W Centerline and TDZ Lights. ....  | 156 |
| Figure 40. | Transformer Housing Installation Details Inset Type Lighting Fixtures. ....   | 157 |
| Figure 41. | Typical Equipment Layout, Inset Type Lighting Fixtures. ....  | 158 |
| Figure 42. | Junction Box for Inset Fixture Installation. ....   | 159 |
| Figure 43. | Typical Taxiway Centerline Lighting Configuration for Non-Standard Fillets (Centerline light spacing for operations above 1,200 feet (365 m) RVR). .... | 160 |
| Figure 44. | Color-Coding of Exit Taxiway Centerline Lights. ....  | 161 |
| Figure 45. | Taxiway Centerline Lighting Configuration for Acute-Angled Exits. ....  | 162 |
| Figure 46. | Controlled Stop Bar Design and Operation – “GO” Configuration. ....   | 163 |
| Figure 47. | Typical Taxiway Centerline Lighting Configuration for Standard Fillets (Centerline light spacing for operations above 1,200 feet (365 m) RVR). ....     | 164 |
| Figure 48. | Taxiway Centerline Light Beam Orientation. ....   | 165 |
| Figure 49. | In-Pavement Runway Guard Light Configuration. ....  | 166 |

Figure 50. Elevated RGL and Stop Bar Configuration..... 167

Figure 51. Typical Light Beam Orientation for In-Pavement RGLs and Stop Bars..... 168

Figure 52. Clearance Bar Configuration at a Low Visibility Hold Point..... 169

Figure 53. Curves for Estimating Primary Load for Taxiway Centerline Lighting Systems..... 170

Figure 54. Typical Elevated RGL Installation Details..... 171

Figure 55. Typical In-Pavement RGL External Wiring Diagram – Power Line Carrier Communication, One Light Per Remote. .... 172

Figure 56. Typical In-Pavement RGL External Wiring Diagram – Power Line Carrier Communication, Multiple Lights per Remote. .... 173

Figure 57. Typical In-Pavement RGL External Wiring Diagram – Dedicated Communication Link..... 174

Figure 58. In-Pavement RGL Alarm Signal Connection..... 175

Figure 59. Controlled Stop Bar Design and Operation – “STOP” Configuration. .... 176

Figure 60. Controlled Stop Bar Design and Operation – Intermediate Configuration. .... 177

Figure 61. Controlled Stop Bar Design and Operation – “STOP” Configuration for A/C 2. .... 178

Figure 62. Typical Layout for Land and Hold Short Lights. .... 179

Figure 63. Typical Wireway Installation Details for Land & Hold Short Lights. .... 180

Figure 64. Sawing & Drilling Details for In-pavement Land & Hold Short Lights. .... 181

Figure 65. Typical Block Diagram for Land & Hold Short Lighting System. .... 182

Figure 66. Typical Curve for Determining Maximum Separation Between Vault and Control Panel with 120-volt AC Control. .... 183

Figure 67. Beacon Dimensions and Wiring Diagram..... 184

Figure 68. Calculations for Determining Wire Size. .... 185

Figure 69. Typical Automatic Control..... 186

Figure 70. 120-Volt AC and 48-Volt DC Remote Control..... 187

Figure 71. Typical Structural Beacon Tower..... 188

Figure 72. Typical Tubular Steel Beacon Tower..... 189

Figure 73. Typical Pre-fabricated Beacon Tower Structure. .... 191

Figure 74. Typical Location of Supplemental Wind Cone. .... 192

Figure 75. Externally Lighted Wind Cone Assembly (Frangible)..... 193

Figure 76. Typical Layout for MALSFS. .... 194

Figure 77. Typical Layout for REIL..... 195

Figure 78. Typical ODALS Layout..... 196

Figure 79. PAPI Obstacle Clearance Surface. .... 197

Figure 80. PAPI Signal Presentation. .... 198

Figure 81. Correction for Runway Longitudinal Gradient. .... 199

Figure 82. General Wiring Diagram for MALSFS with 120-Volt, AC Remote Control..... 200

Figure 83. Typical Wiring Diagram for MALSFS Controlled from Runway Lighting Circuit..... 201

Figure 84. Typical Field Wiring Circuits for MALSFS..... 202

Figure 85. Typical Installation Details for Frangible MALS Structures – 6 foot (1.8 m) Maximum. .... 203

Figure 86. Typical Wiring for REILs Multiple Operation..... 204

Figure 87. Typical Wiring for REIL Series Operation ..... 205

Figure 88. FAA L-880 Style B (Constant Current) System Wiring Diagram. .... 206

Figure 89. FAA L-880 Style A (Constant Voltage) System Wiring Diagram..... 207

Figure 90. PAPI Light Housing Unit (LHU) Installation Detail..... 208

Figure 91. Typical Installation Details for Runway End Identifier Lights (REILs). .... 209

Figure 92. Configuration “A” Electrical Power..... 210

Figure 93. Typical KVA Input Requirements. .... 211

Figure 94. Typical Wiring Diagram for Configuration “A” Electrical Power..... 212

Figure 95. Typical Equipment Layout for Configuration “A” Electrical Power. .... 213

Figure 96. Configuration “B” Electrical Power..... 214

Figure 97. Typical Wiring Diagram for Configuration “B” Electrical Power..... 215

Figure 98. Typical Wiring Diagram for Configuration “C” Power..... 216

Figure 99. Flexible Pavement or Overlay Installation..... 217

Figure 100. Use of Alignment Jig, No Reference Edge Available, Non-adjustable Base and Conduit System. .... 218

Figure 101. Use of Alignment Jig, Reference Edge Available, Non-adjustable Base and Conduit System..... 219

Figure 102. In-pavement Shallow Base Runway Edge End or Threshold Light. .... 220

Figure 103. In-pavement Shallow Base Runway Centerline or TDZ Light .....221

Figure 104. Sawing and Drilling Details for In-Pavement Taxiway Centerline Lights.....222

Figure 105. Wiring Details for Direct- and Base-Mounted Taxiway Centerline Lights.....223

Figure 106. Typical Transformer Housing and Conduit Installation Details for Taxiway Centerline Lights. ....224

Figure 107. Adjustment of Edge Light Elevation for High Snowfall Areas.....225

Figure 108. Cable and Duct Markers.....226

Figure 109. Counterpoise Installation.....227

Figure 110. Power and Control System Block Diagram.....228

Figure 111. Typical PLC Control System Block Diagram. ....229

Figure 112. PC Control System Block Diagram.....230

Figure 113. Typical Standard Details for Runway & Taxiway Edge Lights –High Intensity Light – Non-adjustable Base-mounted. ....246

Figure 114. Typical Standard Details for Runway & Taxiway Edge Lights –Medium / High Intensity Light – Non-adjustable Base-mounted. ....247

Figure 115. Typical Standard Details for Runway & Taxiway Edge Lights –Medium Intensity Light – Stake-mounted. ....248

Figure 116. Typical Counterpoise and Ground Rod Connections .....249

Figure 117. Identification (ID) Tag Detail. ....250

Figure 118. Standard Details for Underground Cable Installation – Typical Multiple Bank Layout. ....251

Figure 119. Standard Details for Underground Cable Installation – Type A. ....252

Figure 120. Standard Details for Underground Cable Installation – Type B.....253

Figure 121. Standard Details for Underground Cable Installation – Type C.....254

Figure 122. Standard Details for Underground Cable Installation – Plowed Cable. ....255

Figure 123. Standard Details for Underground Cable Installation – Plowed Cable. ....256

Figure 124. Standard Details for Taxiway Hold and Guidance Sign – Sign – Single Pedestal. ....257

Figure 125. Standard Details for Taxiway Hold & Guidance Sign – Sign – Multiple Pedestal. ....258

Figure 126. Standard Details for Taxiway Hold & Guidance Sign – Detail A.....259

Figure 127. Standard Details for Pivoting Rotating Beacon Pole – Rotating Beacon & Mounting Bracket Detail. 260

Figure 128. Standard Details for Pivoting Rotating Beacon Pole – Locking Device Detail. ....261

Figure 129. Standard Details for Pivoting Rotating Beacon Pole – Pivot Detail. ....262

Figure 130. Standard Details for Pivoting Rotating Beacon Pole.....263

Figure 131. Standard Details for Wind Cone Foundation (L-807). ....264

Figure 132. Standard Details for Wind Cone – 12 ft. (3.7 m) Wind Cone. ....265

Figure 133. Standard Details for Precision Approach Path Indicators (PAPIs) – PAPI Light Unit Locations.....266

Figure 134. Standard Details for Precision Approach Path Indicators (PAPIs). ....267

Figure 135. Standard Details for Precision Approach Path Indicators (PAPIs) – Section A-A.....268

Figure 136. Standard Details for Runway End Identifier Light Power & Control Derived From Runway Circuit – Profile View. ....269

Figure 137. Standard Details for Runway End Identifier Light Power & Control Derived From Runway Circuit – Plan View.....270

Figure 138. Location of Entrance-Exit Lights (in lieu of guidance signs).....271

Figure 139. Controlled Output Sign Block Diagram.....281

Figure 140. Typical Power Line Carrier System .....283

Figure 141. Load Example for In Pavement RGL Circuit.....288

Figure 142. ALCMS Block Diagram .....291

Figure 143. REL Configuration for Taxiways at 90 Degrees .....295

Figure 144. Angled Configuration.....296

Figure 145. Takeoff/Hold Lights.....297

Figure 146. Runway Intersection Lights .....299

**LIST OF TABLES**

Table 2-1. Straight Taxiway Edge Light Spacing.....8

Table 2-2. Edge Lighting System Design Guide. ....10

Table 2-3. Equipment and Materials.....13

Table 4-1. Longitudinal Dimensions. ....22

Table 4-2. Equipment and Material Used for Low Visibility Lighting Systems. ....37

Table 5-1. Equipment and Material Used for Land and Hold Short Lighting Systems. ....42

Table 7-1. Threshold Crossing Heights. ....60

Table 7-2. Aiming of Type L-880 (4 Box) PAPI Relative to Pre-selected Glide Path. ....60

Table 7-3. Aiming of Type L-881 (2 Box) PAPI Relative to Pre-selected Glide Path. ....61

Table 8-1. Interface of Radio Control with Airport Visual Aids. ....74

Table 13-1. AGL Control System Response Times.....115