SECTION 16500

LIGHTING FIXTURES

PART 1 - GENERAL

1.01 SCOPE

A. Work Included:

All labor, materials, appliances, tools, equipment necessary for and incidental to performing all operations in connection with furnishing, delivery and installation of the work of this Section, complete, as shown on the drawings and/or specified herein. Work includes, but is not necessarily limited to the following:

1. Examine all other specification sections and drawings for related work required to be included as work under Division Sixteen.
2. General provisions and requirements for electrical work.

1.02 SUBMITTALS

A. General

1. Submit certification letter from manufacturers of Lamps and Ballasts, (or alternately, manufacturer's published catalog data) stating/showing the specific lamp and ballast combination comply with manufacturer recommendation and approval for the combined use, shown on the drawings.
2. Provide complete manufacturers catalog data information for each light fixture (luminaire), ballast, lamp, materials, auxiliary equipment/devices, finishes and photometrics.

B. Performance Certification

1. Submit manufacturer's certified lamp and ballast tests report data showing compliance with contract document.
2. Submit manufacturer's letter of certification for each fixture type, confirming the proposed combination of specific lamp, ballast and auxiliary components for each light fixture (luminaire)type will function together correctly and perform in compliance with the requirements of the contract documents as follows:
   "The proposed lamp(s), lamp ballast(s)(where, applicable), lamp sockets and fixture have been tested as an assembly. The proposed fixture products assembly are certified by the manufacturer to function within the required temperature, lumen output, electrical characteristics and operational life described in the contract documents".

C. Light Fixture Samples

1. If requested by the OWNER'S Representative, provide a sample of each fixture proposed as a substitution for a specified fixture. Sample fixture shall be complete with specified lamps, 3 wire grounding "SO" cord and plug for 120-volt 60 Hz, AC plug-in operation. Sample fixtures shall be delivered to the OWNER'S Representative's office for review, the samples shall be picked up within ten (10) working days after review comments have been received; any samples left beyond this time will be discarded by the OWNER'S Representative. Decision of OWNER'S Representative regarding acceptability of any lighting fixture is final.

1.03 QUALITY ASSURANCE (ADDITIONAL REQUIREMENTS)

A. Work and materials shall be in full accordance with the latest rules and regulations as follows. The following publications shall be included in the Contract Document requirements. If a conflict occurs between the following publications and any other part of the Contract Documents, the requirements describing the more restrictive provisions shall become the applicable contract definition:

1. U.L. – Underwriters' Laboratory:
   a. U.L. – 1572: HID Lighting Fixtures
   b. U.L. – 1570: Fluorescent Lighting Fixtures
   c. U.L. – 1029: HID Ballast
   d. U.L. – 935: Fluorescent Lamp Ballast
   e. U.L. – 542: Lamp Holders, Starters, and Starter Holders
2. NEMA-LE4
3. United States Federal Government:
   a. FCC – Part 18: EMI and RFI emissions limitations.
   b. EPA: Energy conservation publications and waste disposal regulations.
4. ETL and C.B.M. certified and approved.
5. Electrical installation standards, National Electrical Contractors' Association:
   a. NEIS/NECA & IESNA – 500: Recommended Practice for Installing Indoor Commercial Lighting Systems.
   b. NEIS/NECA & IESNA – 501: Recommended Practice for Installing Exterior Lighting Systems
   c. NEIS/NECA & IESNA - 502: Recommended Practice for Installing Industrial Lighting Systems.
6. Illuminating Engineering Society – IES:
   a. IES – LM41: Photometric and Reporting
   b. IES – 587: Transient Surge Protection
7. American National Standards Institute:
   a. ANSI – C81
   b. ANSI – C82
   c. ANSI – C62.41: Transient Withstand
   d. ANSI – C78: Lamps
8. State California Code of Regulations - Title-24: Energy Code
9. DALI – Digital Addressable Lighting Interface, shall comply with latest versions of IEC-609929 and NEMA-243. See Specification Section 16575 "DALI Lighting Controls" for additional requirements.

PART 2 - PRODUCTS

2.01 GENERAL

A. Complete Fixture
   1. Provide light fixtures complete including lamps, ballasts, lamp holders sockets, housings, ceiling and wall trim "rings" for each ceiling type, mounting and adapter support brackets, diffusers/lenses and outlet boxes.
   2. Include an allowance of $300.00 to provide a light fixture for each lighting fixture outlet shown on drawings without a fixture type designation.

B. Specific Fixture Requirements and Fixture Schedule Information

1. The catalog numbers included in the description of the various types of lighting fixtures shall be considered to establish the type or class of the fixture with a particular manufacturer only. The fixture length, number of lamps and lamp types, component materials, accessories, mounting type, ceiling, wall and install adapters, operation voltage, and all other components required to fulfill the total description of the fixture based on all drawing information, branch circuits, voltages, specification information, and shall be included in the contract requirements regardless of whether or not the catalog number specifically includes these components.
2. Lighting fixtures shall be the types as indicated in fixture schedule on the drawings and as described in the specifications.
3. All fixtures of the same fixture type shall be the same manufacturer and of identical finish and appearance, unless indicated otherwise on drawings.

C. Manufacturer Certification of Operation

1. Lamps and lamp ballasts shall be recommended and certified by the respective manufacturer(s), to be "matched" to operate correctly together, within the published characteristics, for efficacy, lamp starting, operating life hours, lumen output, power factor, power input, operating line ampere, sound intensity, and temperature.

2.02 BALLASTS (FOR HID & FLUORESCENT LAMPS)

A. General

1. All ballast, lighting fixtures assemblies and components shall be ANSI, ETL approved C.B.M. certified and UL labeled.
2. Ballasts shall provide Class "P" thermal protection.
3. Ballasts shall comply with FCC Part 18 Class-A and NEMA limits as to EMI or RFI and not interferes with normal operation of electrical or electronic data processing equipment.
4. Ballast open circuit voltage, starting voltage, crest voltage and lamp-operating voltage shall comply with requirements of the respective manufacturer of the installed lamps.
5. Lamp ballasts and transformers shall be for use with the specific lamps provided as part of the Contract.
6. Ballasts and lamps shall be suitable for use with automatic occupancy motion sensing type switching "on-off" control systems, with multiple "on-off" cycles per hour, on a 24 hours a day basis. Operation shall be without loss of performance in ballast and/or lamp operating characteristics described in the Contract Documents.
7. Ballasts Fusing
   a. Each ballast shall be independently fused on the incoming line side within ballast compartment.
   b. Alternately the ballast manufacturer may install the equipment fuse inside the ballast.
   c. Provide a label next to ballast cover reading: "Ballast is fused, check fuse prior to relamping". Provide an additional quantity of 10% spare fuses and deliver to Owner.
8. Ballast sound rating Class-A or better. Where sound rating classification is not published, the ballast sound rating shall be the best of product manufactured. Ballasts, which are judged by the OWNER'S Representative to be excessively noisy, shall be removed and replaced at the CONTRACTOR'S expense with low noise ballasts.
9. Electronic solid-state ballasts shall be the product of ballast manufacturer that have been producing electronic ballasts for a minimum of five consecutive years prior to the date of the contract.
10. Ballast shall be designed and supplied to operate on the incoming line voltage system circuits to which the respective ballasts and fixtures are connected.
11. Ballasts shall not contain any PCB (polychlorinated biphenyl).

12. Ballast power factor shall be not less than 0.90, starting and operating. The ballast lamp starting transient line input ampere shall never exceed lamp normal operating ampere by more than 10-percent.
13. Ballast as manufactured by General Electric, Advance, Philips, Universal, Sylvania/Osram or equal.

B. Solid-State Electronic Fluorescent Lamp Ballast
1. Fluorescent ballasts shall be solid-state electronic type ANSI C82.11.
2. Ballast shall operate lamps at voltage frequency exceeding 40 Kilohertz, without visually detectable flicker, flicker index shall not exceed 3-percent. Shall deliver lamp manufacturers normal rated lamp life.
3. Ballast normal operations and life expectancy shall not be affected by lamp failure or sustained open circuit/short circuit.
4. Ballast shall be surge and transient protected to 6000 volts, ANSI-C62.41, Category-A.
5. Maximum total harmonic distortion (THD) created by operation on the line (input) side of the ballast shall not exceed 10-percent.
6. The ballast shall provide an isolated output to the lamps. Metal ballast case shall be positively grounded to the light fixture metal housing.
7. The ballast shall incorporate transient surge protection to prevent damage to the ballast due to line side transients.
8. The ballast lamp current crest factor shall be 1.7 or less (ratio of peak to RMS current).
9. The ballast factor (BF)shall be not less than 0.87 for normal light output unless indicated otherwise on the drawings.
10. Program Start - Integrated circuit (IC) program start ballast shall energize (preheat) the lamp cathode "heater" filament for a programmed time duration prior to transition phase to lamp arc ignition and immediately deenergize the cathode after arc is established and lamp is operational. The ballast shall precisely control the cathode temperature and duration to increase lamp start "on-off" cycles prior to lamp failure to approximately 35,000 starts. The ballast shall reduce the "black-end" lamp condition resulting from frequent lamp "on-off" cycles. The Program Start ballast shall provide Automatic End of Life (EOL)lamp current shut-off, when a lamp fails.

D. Core & Coil, Non-Solid-State HID Lamp Ballast
1. Ballasts including metal halide and high-pressure sodium fixtures shall be provided with constant wattage autotransformer(CWA)Ballasts.
2. If a core and coil CWA ballast is not available that complies with the contract documents, then provide solid-state electronic HID ballast.
3. The electromagnetic core and coil shall be Class-H (180° Centigrade) or higher temperature insulation, no exposed energized parts.
4. Capacitor with self-contained internal bleeder resister, UL – 1029, 100 degree C rated, dry capacitor.
5. Igniters shall withstand not less than 10,000 hours of continuous pulsing and 6-months of continuous open circuit operation without failure.
6. Ballast factor (BF) shall be 1.0.

E. Solid-State Electronic Metal Halide Lamp Ballast
1. Solid-state electronic for low wattage "probe-start" metal halide type lamp operation.
2. Lamp current crest factor (ratio of peak to RMS current) shall not exceed 1.5.
3. Operate lamps at a frequency of less than 200 HZ to minimize acoustic resonance inside the lamp arc tube and minimize lamp flicker.
4. Ballast factor (BF) shall be 1.0.
5. Automatic ballast thermal protection and automatic shutdown at end of lamp life (EOL) protection.
6. Total harmonic distortion (THD) on the input line side shall not exceed 16-percent.

F. Dimming Ballasts and Lighting Control System Ballasts

1. General

   a. The light fixture ballasts shall comply with the recommendations of the lighting control system manufacturer, as to ballast type and ballast manufacturer sources. Provide documentation with shop drawings certifying compliance with the requirements.

2. Fluorescent lamp dimming

   a. One or multi-lamp rated dimming ballast shall be provided for fluorescent lamp dimming systems, as recommended by the lighting control system manufacturer.

G. Emergency Lighting

1. Light fixtures shown connected to both normal power and external emergency power branch circuits, shall be furnished with separate lamp ballasts for the normal and emergency power circuits.
2. The ballast(s) for the lamps connected to the external emergency branch circuit shall be in a separate wireway isolated and barriered from the ballast(s) for the lamps connected to the normal power branch circuits. The fixture shall be factory labeled "emergency" and "normal" on the respective wireways and ballasts.

H. Tandem Ballast Connections

1. Ballasts in one (1) or three (3) lamp fluorescent fixtures, when fixture is recessed mounted and within eight (8) feet of each other, or if surface on pendant mounted within (1) one foot of each other, shall be furnished with a tandem wiring harness connected to inboard Ballasts of master fixture, to be field connected to inboard ballast of adjacent fixture. Night-light or emergency light fixtures shall be exempt from this requirement.

I. Tabulation Ballast Performance Requirement

1. Compact Fluorescent Lamp (CFL) Ballast Characteristics – Table #2

Lamp Characteristics			Lamp/Quan. Each Ballast	Ballast Elec. Input Max. Load			
				ANSI Input Watts		Input - VA	
Designation	NOL.	Watts		& BF	& BF	& BF	& BF
				0.87		0.87	
T5/CFL	22.5"	40	1	40	-	44	-
T5/CFL	22.5"	40	2	72	-	74	-
T5/CFL	22.5"	40	3	103	-	106	-
T5/CFL	22.5"	40	4	-	-	-	-
				0.90BF		0.90BF	
T5/CFL-HO	20.7"	55	1	58	-	61	-
T5/CFL-HO	20.7"	55	2	104	-	107	-
T5/CFL-HO	20.7"	55	3	-	-	-	-
T5/CFL-HO	20.7"	55	4	-	-	-	-

2. High Intensity Discharge (HID) Lamp Ballast Characteristics – Table #3

Lamp Characteristics		Ballast Maximum Electrical Input Load			
Designation	Lamp Watts	ANSI Input Watts		Input - VA	
		Core/Coil	Electronic	Core/Coil	Electronic
		Probe Start Metal Halide			
Metal Halide – MH	35/39	53	45	170	55
Metal Halide - MH	50	70	57	168	61
Metal Halide - MH	70	90	83	229	87
Metal Halide - MH	100	129	113	140	117
Metal Halide - MH	150	189	169	222	170
Metal Halide – MH	175	211	195	218	205
Metal Halide - MH	250	296	-	306	-
Metal Halide - MH	400	461	-	482	-
Metal Halide - MH	1000	1080	-	1083	-
Metal Halide - MH	1500	1615	-	1636	-
		PULSE START – HID			
Metal Halide	100	-	-	-	-
Metal Halide	175	208	-	222	-
Metal Halide	200	232	-	250	-
Metal Halide	350	400	-	46	-
Metal Halide	400	452	-	471	-
Metal Halide	750	818	-	840	-
Metal Halide	1000	1080	-	1081	-
HPS	50	66	72	128	166
HPS	70	95	-	111	-
HPS	100	138	-	144	-
HPS	150	190	-	204	-
HPS	200	250	-	278	-
HPS	250	295	-	305	-
HPS	310	365	-	406	-
HPS	400	464	-	471	-
HPS	1000	1100	-	1164	-

4. Ballast table notes:
   a. ANSI Watts = Ballast input watts @ 25°C (77°F) ambient; less than 1 ft. per minute air flow; horizontal lamp position. Greater than 9-inch lamp to lamp spacing for fluorescent lamps; Not less than 100 hours (seasoning) on new lamp operation prior to testing; perform test reading 30 seconds after test ballast/lamp operation is initiated.
   b. BF = (Ballast factor). (Lamp lumen output of specified ballast) ÷ (lamp lumen output with test laboratory "reference test ballast"). Lamp ballast factor shall not be less than described in the Contract Documents.
   c. HO = High output rated lamps and ballasts. (Note: All linear fluorescent lamps and ballasts shall be "normal" output rated , unless noted otherwise.)
   d. HPS = High pressure sodium.
   e. PS = Program start rated lamps and ballasts. (Note: all linear fluorescent lamps and ballasts shall be instant start rated, unless noted otherwise.)

2.02 LAMPS

A. General
   1. Lamps shall be new, of wattage and type indicated. Each fixture or lighting outlet shall be supplied with the proper lamp(s)
   2. Lamps shall comply with the characteristics as described in the lamp tables below, except where indicated otherwise on the drawings.
   3. Lamps shall comply with limits on mercury and classification as non-hazardous waste as follows:
      a. Federal EPA – Toxicity Characteristics Leaching Procedures (TCLP).
      b. State of California – Total Threshold Limit Concentration (TTLC).
   4. Lamps shall be as manufactured by General Electric, Philips, Osram or Sylvania.

B. Incandescent Lamps
   1. General-purpose incandescent "A" style lamps shall be inside frosted, medium base for 200 watts and smaller.
   2. Reflector lamps shall be PAR-20, PAR-30 or PAR-38 as required, unless otherwise specified in fixture schedule.
   3. Incandescent lamps in non-enclosed fixtures and fixtures without lens/diffuser shall be rated for "open" fixture operation.

C. Fluorescent Lamps
   1. Linear fluorescent shall be energy saving type and bi-pin operation. Rapid-start, Program Start or instant start as indicated in the contract documents.
   2. Compact fluorescent lamps.
   3. Average lamp life shall not be less than the following, based on 3 hours "on" operation and 20-minute "off" for each start cycle, when matched in combination with the specific lamp ballast and with the respective light fixture, unless noted otherwise:
      a. Linear fluorescent 20,000 hours.
      b. CFL – 20,000 hours and as noted in the lamp tables.
      c. HID – as noted in the lamp tables, based on 12-hours "on" operation for each start cycle.
      d. Incandescent – as noted in the lamp tables.

D. High Intensity Discharge Lamps HID
   1. Provide proper base up, base down, horizontal, operating configuration for the fixture and lamps being furnished.
   2. HID lamps (indoor or outdoor locations).
      a. HID lamps used outdoors or in damp/wet locations shall only be used in fully enclosed, lensed fixtures.
      b. Open type fixtures with HID lamps used indoors shall only be ANSI-"TYPE-0" protected lamps and protected lamp sockets or shall only be fully enclosed, lensed fixtures.
      c. Enclosed/lensed fixtures with HID lamps, shall be rated for "ARC-TUBE Containment"
   4. Lamps in non-enclosed light fixtures shall be equipped with automatic switching device to de-energize the lamp when the lamp outer glass envelope is broken.
   5. High-pressure sodium lamps shall be clear unless noted otherwise on drawings.
   6. Metal halide lamps shall be clear or coated as indicated on the drawings.
   7. Lamp socket and lamp "burning" position of operation rating (i.e., base-up, base-down, horizontal) shall comply with the actual lighting fixture installation location.

D. Tabulation Lamp Performance Requirement

1. Linear Fluorescent Lamp Characteristics – Table #1
20,000 Hours Average Life @ 3 Hours per Start(cont'd)

Lamp Designation		Lamp	Lamp	Initial	Lamp	Lamp
Diam.	Type	NOL.	Watts	Lumens*	CCT(K)	CRI
[ATTN: Spec. Writer, Premium performance T-8 lamps have a higher initial purchase cost, but may be justified for improved "Scotopic" footcandle performance, better energy performance and improved color rendition. Philips Lamps, catalogs a super premium T-8, 32 watt, 48" lamp, 24,000 hours, rated 3200 initial lumens, 86 CRI for 3000K, 4100K & 5000K versions, but no other manufacturer has an equivalent output rating T-8 lamp!]						
T5	FP28/35	48"	28	2610 2900	3500	82

2. Compact Fluorescent Lamp (CFL) Characteristics – Table #2

Lamp Designation		Lamp	Lamp	Initial	Lamp	Lamp
Diam.	Type	NOL.	Watts	Lumens*	CCT(K)	CRI
[ATTN: Spec. Writer, CFL lamps may be a better choice for 2'x2', and 1'x2' fixtures, when compared to "U-lamps", because of the superior lumen/energy efficiencies of CFL. However, "U-lamps" are lower initial purchase price.]						
a. Twin Tube/4-PIN/2G11						
T5/CFL	F40BX/35	22.5"	40	3150	3500	82
b. High Output, Twin Tube/4-PIN/2G11 (12,000-Average Life/Hours)						
T5/CFL	F55BX/35/HO	20.7"	55	4800	3500	82

3. High Intensity Discharge (HID) Lamp Characteristics

Lamp Designation		Average	Lamp	Initial	Lamp	Lamp
Identification	Type	Life/Hrs	Watts	Lumens*	CCT(K)	CRI
e. High Pressure Sodium, Universal Mounting Position, Mogul Base & Socket						
HPS	HPS50	24,000	50	**4,000**	1900	22
HPS	HPS70	24,000	70	6,400	1900	22
HPS	HPS100	24,000	100	9,500	2000	22
HPS	HPS150	24,000	150	15,000	2000	22
HPS	HPS200	24,000	200	22,000	2100	22
HPS	HPS250	24,000	250	28,000	2100	22

Lamp Table Notes:

1. Fluorescent lamp lumen output listed in the tables above are based on lamp ballast, solid-state electronic ballasts, operating at 40kHz or greater.
2. Definition of terms, typical for all lamp schedules:
   a. Average Life/Hrs. = Lamp expected average operating hours when 50% of lamps have failed.
   b. Beam angle = The angle in degrees for the light dispersion, "narrowspot" (SP), "medium" (M), or "wide flood" (FL).
   c. CCT(K) = Lamp operating rated color temperature, chromaticity - Kelvin scale.

d.	CRI	=	Lamp minimum Color Rendering Index.
e.	CBCP	=	Center beam candle power.
f.	Diam.	=	Nominal lamp diameter,
g.	*Initial Lumens, Lumen output after 100 hrs. lamp operation to condition the lamps using a laboratory standardized ballast	=	• 25 degrees centigrade (C) ambient operating temperature for fluorescent lamp • 30 degrees centigrade (C) for HID lamp * Two different lamp lumen outputs are listed for T5 linear fluorescent lamps, the 1st is @ 25°C ambient the 2nd is @ 35°C ambient
h.	NOL	=	Nominal length of lamp.
i.	Watts	=	Rated lamp watts, not including ballast @ 25 degrees Centigrade (C) ambient

j. See ballast table notes for additional definition of terms

2.03 LIGHT FIXTURES (LUMINAIRES)

A. General

1. Lighting fixtures shall have all parts, ballasts, sockets, support attachments, trim flanges and fittings necessary to complete and properly install the fixture at the indicated installation locations. All fixtures shall be provided with lamps of size and type specified.
2. Ceiling and/or wall surface mounted lighting fixtures shall not have any exposed chase nipples or conduit knockouts visible to view within fixture housing. Lighting fixtures mounted in continuous rows shall have chase nipples or conduit knockouts between lighting fixture housing, but shall not have visible chase nipples/conduit
3. Where fixture color is indicated to be selected by the ARCHITECT and/or OWNER'S Representative, provide two color chip samples for each color for review.
4. Recessed fixtures with attached junction box shall be provided with a junction box permanently attached to the plaster ring so that the junction box is accessible through the fixture opening when the fixture is removed. Connection between fixture and pull box shall be flexible metal conduit with not less than 16 AWG "AF" or "CF" type fixture rated copper wires, high temperature wire insulation for not less than 600 volts A.C. The flexible conduit shall be sufficient length, so that when the fixture is removed, the pullbox is readily accessible.
5. Recessed fixtures shall be Underwriters' Laboratory approved for recessed installation with plaster frame and attached pull box. Lamp enclosure, reflectors and finish wiring shall not be installed until plastering is completed. Exposed finish trim shall not be installed until finish painting of the adjacent surface is completed.
6. The fixture shall bear Underwriters' Laboratory label of approval for the wattage and installation indicated.
7. Light fixtures installed outdoors, in damp or wet locations shall be U.L. labeled for said location as "damp-location" and "wet-location" for the respective installation location.
8. Fixtures in contact with thermal/building insulation, shall be UL listed and rated for direct contact installation in thermal insulation systems.
9. Lamp auxiliary support brackets shall be heat-resistant, non-dielectric. Alternatively, metal auxiliary lamp support brackets shall be electrically isolated from the fixture, to prevent glass decomposition.
10. Lighting fixtures installed in masonry and/or concrete construction. The fixture housing shall be rated for "concrete-pour" installation location.

11. Provide a permanent label inside each light fixture stating the following relamping information. Not less than 0.125-inch high black alphanumeric characters on white background.

"Replacement lamp(s) installed in this light fixture _must comply with the following criteria:

*: *CRI*	*: *Lamp Watts*
*: *CCT-K*	*: *Lamp Lumens*

Only lamp rated * type lamp ballast shall be installed in this fixture."

*Insert the value required for the specific lamp required by the Contract Documents for each light fixture.

B. Lens and Diffusers
   1. Acrylic plastic or Plexiglas for the light fixture diffusers or fixtures lenses, shall be 100-percent virgin material.
   2. Thickness of not less than 0.125-inch, as measured at the "THINIST" portion on the diffuser or lens. However, thickness shall be increased to sufficient construction and camber to prevent the lens and diffusers from having any noticeable sag over the entire normal life of the installation.
   3. Diffusers shall be formed from cast sheet by a vacuum and/or pressure technique.
   4. Lighting fixtures containing lamps with dichroic reflectors and light fixtures with non-dichroic lens/diffuser, shall be rated for high temperature lamp operations resulting from lamp heat redirected (reflected) back into the fixture.

C. Fixture/Luminaire Internal Wiring
   1. Provide wiring between fluorescent lampholders and associated operating and starting equipment. Provide ballasts/transformers inside lighting fixture.
   2. Where there are two or more fluorescent lamps in a single luminaire, and multiple level intensity control is indicted on specifications or drawings, multiple-lamp ballasts shall be used to the greatest extent possible and the following tandem wiring configurations shall apply:
      a. If "inboard-outboard" wiring or multi-intensity light switching controls are specified for (odd-quantity) multi-lamp luminaires, then the two outboard lamps shall be connected to a single two-lamp ballast within each luminaire. The inboard lamps of two adjacent luminaires shall be tandem wired, that is, connected to a two-lamp ballast within one of the luminaires.
      b. A one-lamp ballast may be used if a luminaire with ballast is separated by more than 10 feet from any other same type luminaire with a ballast, or if the nearest luminaire is on another control circuit. Otherwise, a lamp in one luminaire shall be tandem wired, that is, connected to a multi-lamp ballast in another luminaire.
   3. Wire insulation for ballast/lamps employing igniters, shall be rated and U.L. listed for the igniter pulse voltage.
   4. Light fixture internal lamp sockets; installation of lamp sockets and ballasts; grounding of lamp sockets and ballasts; and wiring connections, shall all comply with the recommendations of ballast manufacturer and lighting control system manufacturer.

D. Lampholders (Sockets) and Supports
   1. Provide fluorescent luminaire lamp sockets that are white, constructed of high temperature heat-resistant plastic or ceramic/porcelain.
   2. When electronic solid-state ballasts are provided, fluorescent lamp sockets for 4'-0" lamps shall be of the "knife edge" type. The lamp sockets providing the tightest electrical connection shall be furnished.
   3. Lamp supports shall be used as recommended by lamp manufacturer.
   4. Rigidly and securely attach lampholder to the luminaire enclosure.

5. Provide lampholders and sockets suitable for specified lamps, and position the lamps in optically correct spacing and relationship to lenses, reflectors, filters, and baffles.
6. Lampholder location shall provide properly located starting aid, as specified by the lamp manufacturer.
7. Lamp sockets in fixtures shall be compatible with the respective specified lamp(s), as recommended by the lamp manufacturer and shall provide specified lamp operational performance.
8. Provide horizontal position(± 15-degree) lamp and lamp socket to automatically ensure lamp position, for lamps requiring horizontal only operation lamps, to ensure correct horizontal lamp install position.
9. Lamp sockets shall be rated for not less than actual volts of the igniter starting of the lamp.

E. Enclosed and Non-Enclosed HID Fixture Operation
1. HID light fixture shall be rated to contain hot lamp fragments (up to 1100°C) resulting from an HID lamp that may shatter (rupture) while operating.
2. HID lens/diffuser shall be rated to filter control short wave ultra violet (UV) from the HID lamp in the event the HID lamp shatters (ruptures). Where the lens/diffuser does not provide UV filter control, provide automatic "cutoff" operation in the light fixture as described below. Enclosed fixtures shall comply with UL-1572.
3. HID lamps, installed in non-enclosed light fixtures or installed in light fixtures not rated to contain hot lamp fragments, the lamp shall be rated for "open" fixture operation. The fixture shall provide automatic "cutoff" of electrical power to the lamp in the event the lamp(s) shatter/rupture.

F. Emergency Ballast Lighting
1. General
   a. Self-contained emergency ballast containing batteries, battery charger, solid-state electronic control and lamp/ballast operation, contained within a metal case, red finish case color.
   b. UL – 924, listed Emergency Lighting and Power Equipment, for installation inside and/or attached to lighting fixtures.
   c. The emergency ballast unit(s) shall be provided inside each respective emergency light fixture by the fixture manufacturer.
   d. Normal operating temperature range from 0-degrees Centigrade up to operating ambient temperature inside respective lighting fixture, but not less than 50-degress Centigrade.
   e. Provide a permanent label inside each emergency light fixture stating as follows, not less than 0.125-inch high black alphanumeric characters on a white background:
      "Warning – this fixture provides more than one electric power source. Disconnect both normal and emergency sources including battery sources prior to opening fixture. Written permanent records documenting regular (every 30 days) emergency lighting function testing results shall be kept on file by the OWNER."
   f. As manufactured by Bodine Inc.; or IOTA-Engineering.
2. Operation
   a. Emergency mode
      When external AC electrical power fails, the emergency ballast shall immediately and automatically switch to emergency mode. Maintain emergency lamp(s) illumination, while operating from the internal battery/electronics during the power failure for not less than 90-minutes continuous duration.
   b. Normal Mode
      When AC electrical power is restored, automatically switch lamp(s) operation to external AC operation and begin battery charging mode.

c. Battery Recharge Mode
The battery charger shall automatically fully recharge discharged batteries in less than 24-hours, and prevent overcharging of the batteries, while maintaining a "float-charge" on the batteries.

d. The emergency ballast shall operate not less than (2)-lamps in multi-lamp light fixtures and (1)-lamp in single lamp light fixtures. When operating in emergency mode, the lamp lumen output of each lamp shall be not less than 30-percent of the lamp normal full lumen output rating of one lamp. The lamp-lumen output shall be 100-percent of the lamp normal full lumen output rating when operating in normal mode.

e. The emergency ballast shall provide cold-strike start and hot-restrike operation of the fixture lamp(s).

f. Periodic automatic, internal self-test, simulating normal power loss and actual operation of emergency lamps on internal battery power. Auto self-test shall occur not more than 30 day intervals. Audible and visual trouble alarm display, with manual alarm reset/silence, for problems identified by autotest functions.

3. Electrical Characteristics

a. Emergency ballast shall operate on the same input AC voltage as the normally "hot" branch circuit supplying the respective light fixture. Maximum line input load shall not exceed 15-percent more than normal fixture electrical load.

b. The emergency ballast shall be compatible for correct operation with the specific lamp/ballast combination contained in the respective light fixture.

c. The emergency ballast shall be compatible with switched (on-off), non-switched (continuously on) and dimmer controlled lighting fixtures/circuits.

4. Components

a. Sealed nickel cadmium batteries, maintenance-free, rated for continuous operation in high ambient temperature, with 7-10 year operational life expectancy.

b. When standing on the floor below the fixture the emergency ballast test/monitor control panel shall be visible and readily accessible when the fixture is installed. The control panel shall provide:

1) Charging indicator visual annunciator to display the charger and battery status.

2) Momentary test switch/pushbutton to manually simulate power failure test.

2.04 LIGHTING STANDARDS (SUPPORT POLES, POLE MOUNTED LIGHTING FIXTURES AND LUMINAIRES)

A. General

1. Lighting poles, pole bases, pole arms, lighting fixtures (luminaires), supports with all lighting pole attachments and anchors shall be designed and constructed to withstand not less than 100 mile per hour steady horizontal wind loading and 130 mile per hour horizontal wind gust loading, without any damage to the lighting standards.

2. Provide tamper-resistant "hand-hole" and cover on the pole, for access into wiring terminations inside the pole. Provide ground "lug" attachment for equipment bond conductor.

3. Provide factory applied weather protective base undercoat and final finish on all exposed and internal components. Color as indicated or as selected by OWNER'S Representative.

B. Base Plate

1. Provide a base plate at the bottom of each pole to attach and secure the pole to the pole anchor bolts. The base plate shall be permanently attached to the bottom of the pole.

C. Anchors

1. Anchor bolts shall be threaded the entire bolt length, not less than four (4) bolts for each pole equally spaced around the pole base. Provide a minimum of two threaded nuts for each anchor bolt. Install a nut on the top and bottom sides of each base plate anchor bolt location. Not less than four (4) threads shall be exposed after pole is installed and leveled.

PART 3 - EXECUTION

3.01 LIGHT FIXTURE INSTALLATION

A. General

1. The CONTRACTOR shall verify actual ceiling and wall construction types as defined on the Architectural drawings and furnish all lighting fixtures with the correct mounting devices, trim rings, brackets whether or not such variations are indicated by fixture catalog number. The CONTRACTOR shall verify depth of all recessed lighting fixtures with Architectural drawings prior to ordering fixtures. Any discrepancies that would cause recessed lighting fixtures not to fit into ceiling shall be reported to the OWNER'S Representative prior to release of order to the supplier of the fixtures.
2. On acoustical tile ceilings, fixture outlets shall be accurately located in the center, at the intersection of the four corners or at the center of the joints of two tiles.
3. The CONTRACTOR shall aim the exterior adjustable lighting fixtures after dark in the presence of, and at a time convenient to the OWNER'S Representative.
4. Fixtures shall be ordered and furnished to operate correctly on the branch circuit voltage connected to the respective fixture as shown on the site plan and floor plan electrical drawings. The voltages shown on the fixture schedule are for generic fixture information only.
5. Install and connect lighting fixtures to the circuits and control sequences indicated on the drawings and to comply with respective manufacturer's instructions/ recommendations.
6. Provide conduit and DALI Loop (Bus) communications lighting control network circuit connections, to each light fixture with DALI ballasts.

B. Lighting fixtures installed in ceiling support grids - suspended lay-in "T-bar" and concealed spline ceilings.

1. Provide two seismic clips at opposite ends of each recessed light fixture, the clip shall connect to the ceiling grid main runners and the light fixture. The light fixture with seismic clips and ceiling grid runner connections shall resist a horizontal seismic force equal to the total weight of the light fixture assembly.
2. Each light fixture weighing 40 pounds or less and where the respective ceiling grid system is "heavy duty" type, shall be suspended directly from the ceiling grid or shall be suspended independent of the ceiling grid support system as approved by the AHJ. Each light fixture weighing more than 40 pounds or where the ceiling grid system is not a "heavy duty" type, shall be supported independent of the ceiling grid and independent of ceiling grid support system.
3. Each light fixture supported independent of the ceiling grid system shall be supported with a minimum of four taut independent support wires, one wire at each fixture corner.
4. Each light fixture supported directly from the ceiling grid or ceiling grid support system shall be additionally connected with a minimum of two independent slack safety support wires. One wire at each opposite diagonal fixture corner. Each 3 ft. x 3 ft. and larger light fixture shall be supported in the same manner, except provide a minimum of four independent slack safety wires, one at each fixture corner.

5. Light fixtures surface mounted to a suspended ceiling shall be installed with a one and one-half inch steel – "C" channel which spans across and above a minimum of two parallel main ceiling grid "runners" and concealed above the ceiling. Each channel or angle member shall be provided with a minimum of two threaded studs for attaching to the fixture housing through the lay-in ceiling tile. Two steel "C" channel members shall be installed for each four-foot (or smaller) fixture. Install the channels within six inches of each end of the light fixture to span a minimum of two ceiling grid parallel main runners. Provide two seismic clips connecting the ceiling grid main runners to each steel – "C" channel. Provide a not less than two (2) taut independent support wires connecting to each channel. Bolt the light fixtures to the threaded studs on the channels or angles, to support the light fixture tight to the ceiling surface.

C. Fixture Supports

1. The support wires for light fixture support shall be 12-gauge steel (minimum). The wires including their building and light fixture attachments shall provide support capacity of not less than four times the weight of the light fixture assembly. Provide additional light fixture support wires and building anchors to meet these requirements, as part of the contract. The support wires shall be anchored to the building structural elements above the ceiling.
2. Pendant mounting fixtures shall be supplied with swivel hangers. Fixtures shall swing in any direction a minimum of 45 degrees of gravity, position. Fixtures shall have special stem lengths to give the mounting height indicated on the drawings. Stem to be single continuous piece without coupling, and to be finished the same color as the canopy and the fixture, unless otherwise noted. The CONTRACTOR shall check all lock nuts and set screws to rigidly secure the swivel socket to the stem, and the stem to the outlet box.
   Fixtures shall be plumb and vertical. Where obstructions occur restricting 45 degrees free-swing of fixtures, the fixtures shall be "guy" wired to prevent fixtures from striking obstructions. The OWNER'S Representative shall approve method of guying. Swinging fixtures shall have an additional safety hanger cable attached to the structure and the fixture at each support, with the capacity of supporting four times the vertical weight of the light fixture assembly.
3. Suspended fixtures weighing in excess of 40 pounds shall be supported independently of the fixture outlet box. Provide "air craft" (minimum 12 gauge) steel hanger cable for suspended fixtures route cable concealed or in pendant where possible. Each cable attachments shall support four times the weight of the fixture assembly. Securely attach the cable to the building structure.
4. Surface mounted fixtures installed on drywall or plaster ceilings and weighing less than 40 pounds may be supported from outlet box. Provide structural supports above drywall or plaster ceilings for installation of fixtures weighing more than 40 pounds and secure fixture to structural supports. The use of toggle bolts is prohibited.

C. Recessed Lighting Fixtures - Fire Rated Building Surfaces

1. Lighting fixtures recessed in ceiling or wall which has a fire resistive rating of 1 hour or more shall be enclosed in a fully enclosed backbox (except over fixture lens/diffuser). The material used to fabricate the "enclosed backbox" shall have a fire rating equal to that of the respective ceiling or wall.
2. The space from the fixture to the box enclosure shall be a minimum of 3-inches.
3. The backbox shall be concealed behind the fire rated ceiling and wall finish surface. The light fixture shall be provided with lamp ballast rated for (normal light output) operation in a "high" ambient temperature.

3.02 LAMPS

A. Fluorescent and HID lamps controlled by dimming equipment shall be operated (aged) for 100 continuous hours without interruption, at 100-percent full lumen output prior to occupancy of the building by the OWNER.

B. Lamps shall be the type and manufacturer as recommended by the dimming system manufacturer.

C. Install all lamps in each light fixture.

D. Lamp and light fixture use during construction:
   1. All lamps in lighting fixtures that have been operated (ON) for a total of more than 300 hours prior to final completion of the contract notice of completion, shall be relamped by the CONTRACTOR. Remove the existing lamps with more than 300 hours of illuminated operation and provide new lamps of the type required by the contract documents, install lamps in respective light fixtures, typical for the following lamp types:
      a. Linear fluorescent.
      b. Compact fluorescent (CLF).
      c. H.I.D.
      d. Incandescent.

3.03 LENS AND DIFFUSERS

Lens, diffusers, internal reflectors shall be completely cleaned of all dust, dirt and fingerprints after the installation of the light fixtures and lamps, and after all trades have completed work and prior to occupancy of the facility by the OWNER.

3.04 BALLASTS

A. Ballasts remote from the lighting fixture, mounted as shown on the drawings and designed for remote operation. Additional wiring and conduit shall be provided whether shown on the drawing or not, between lighting fixture and remote Ballasts with required quantity of "THHN" wire installed in conduit to operate said fixture(s).

B. Provide proper type and quantity of conductors with conduit system for proper operation of dimming system, whether or not shown on drawings.

C. CONTRACTOR shall tandem wire one (1) lamp or three (3) lamp fluorescent fixtures when fixture is recessed mounted and within eight (8) feet of each other or if surface or pendant mounted within one (1) foot of each other. To accomplish tandem wiring, a tandem wiring harness shall be installed between inboard master ballast and inboard slave lamp located in adjacent fixture. Night-light or emergency light fixtures shall not apply.

3.05 FLUORESCENT LIGHT FIXTURE TANDEM WIRING CONNECTIONS

A. The contractor shall provide tandem wiring whether or not shown on the drawing for fluorescent lighting fixtures conforming to all of the following criteria:
   1. Light fixture contains fluorescent lamp ballast.
   2. Odd number of lamps in light fixture (i.e., 1 lamp, 3 lamps, 5 lamps, etc.).
   3. Light fixtures are recess mounted within 10 ft. of each other; light fixtures are surface mounted or suspended/pendent mounted within 1 ft. of each other.
   4. Light fixtures are located in the same room.

B. Provide the tandem wiring connections between respective light fixtures as follows:
   1. The tandem wiring harness shall be the product of the respective lighting fixture manufacturer.
   2. The tandem connection shall provide pre-assembled wiring harness connecting two (2) fluorescent lamps in adjacent lighting fixtures with a master lamp ballast, remote adjacent fixture slave lamp.
   3. The wiring harness shall contain the wiring in flexible steel conduit or enclosed metal raceway/jacket for installation in an air plenum.

C. Delete tandem wiring requirement and provide individual and multi-lamp Ballasts in each respective light fixtures under one or more of the following conditions.
   1. Lighting fixtures are shown as night-light or emergency light type fixtures do not require tandem wiring.
   2. Fluorescent dimming Ballasts do not require tandem wiring.

3.06 COMMISSIONING LIGHTING FIXTURES (ADDITIONAL REQUIREMENTS)

A. General
   1. Verify correct lighting control configurations and operation in each room.
   2. Simulate normal source power failure by "opening" (turn off) building main service disconnect and verify connections and operation of each emergency lighting fixture.
   3. Confirm "EXIT" sign directional arrows are visible in each "EXIT" sign.
   4. Verify light fixture support-hangers, ceiling grid clips and seismic restraints comply with the Contract Documents.
   5. Remove protective shipping/installation shields on fixtures. Verify fixtures and lamps are clean and free of construction debris. Clean light fixtures found to be contaminated or dirty.
   6. Setup, program and function test lighting control systems to perform each of the indicated control functions, area/room zones and sequences.
   7. Provide "aiming", directional adjustment of light fixtures, both indoor and outdoor. Aiming shall comply with manufacturer's aiming diagrams, and as directed by Owner's Representative.

B. Sample spot-check in each room the following lighting fixture information:
   1. Lamp type and performance data.
   2. Ballast type and performance data.
   3. Combined lamp/ballast certification of performance and compatibility by respective manufacturer.
   4. Verify instructional signage is placed inside each lighting fixture in compliance with Contract Documents.

END OF SECTION