Project Manual

VOLUME 2 OF 2
Including Divisions 15 and 16

for the

ELIZABETHTOWN FIRE DEPARTMENT
FIRE STATION #2
ELIZABETHTOWN, KENTUCKY

for the

City of Elizabethtown
200 West Dixie Avenue
Elizabethtown, KY. 42702

April 18, 2019

RBS 18005

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FIRE STATION #2 ELIZABETHTOWN, KENTUCKY

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SECTION 15000 - GENERAL PROVISIONS - MECHANICAL

1. GENERAL

A. The Advertisement for Bids, Instructions to Bidders, Bidding Requirements, General, Special and Supplementary Conditions, and all other contract documents shall apply to the Contractor's work as well as to each of his Sub-Contractor's work. All manufacturers, suppliers, fabricators, contractors, etc. submitting proposals to any part if for work, services, materials or equipment to be used on or applied to this project are hereby directed to familiarize themselves with all documents pertinent to this Contract. In case of conflict between these General Provisions and the General and/or Special Conditions, the affected Contractor shall contact the Engineer for clarification and final determination.

B. Each Proposer shall also be governed by any unit prices and Addenda insofar as they may affect his part of the work or services.

C. The work included in this division consists of the furnishing of all labor, equipment, transportation, excavation, backfill, supplies, material, appurtenances and services necessary for the satisfactory installation of the complete and operating Mechanical System(s) indicated or specified in the Contract Documents.

D. Any materials, labor, equipment or services not mentioned specifically herein which may be necessary to complete or perfect any part of the Mechanical Systems in a substantial manner, in compliance with the requirements stated, implied or intended in the drawings and/or specifications, shall be included as part of this Contract.

E. It is not the intent of this section of the specifications to make any Contractor, other than the General Contractor responsible to the Owner, Architect and Engineer. All transactions such as submittal of shop drawings, claims for extra costs, requests for equipment or materials substitution, shall be routed through the General Contractor to the Architect then to the Engineer. Also, this section of the specifications shall not be construed as an attempt to arbitrarily assign responsibility of work, material, equipment or services to a particular trade or Contractor. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be optional.

F. It is the intent of this Contract to deliver to the Owners a "like new" project once work is complete. Although plans and specifications are complete to the extent possible, it shall be the responsibility of the Contractors involved to remove and/or relocate or re-attach any existing or new systems which interfere with new equipment or materials required for the complete installation without additional cost to the Owner.

G. In general, and to the extent possible, all work shall be accomplished without interruption of existing facilities operations. The Contractor shall advise the Owners at least two weeks prior to the interruption of any services or utilities. The Owners shall be advised of the exact time that interruption will occur and the length of time the interruption will last. Failure to comply with
this requirement may result in complete work stoppage by the Contractors involved until a complete schedule of interruptions can be developed.

H. Definitions and Abbreviations

(1) Contractor - Any Contractor whether proposing or working independently or under the supervision of a General Contractor and/or Construction Manager and who installs any type of mechanical work (Controls, Plumbing, HVAC, Sprinkler, Gas Systems, etc.) or, the General Contractor.

(2) Engineer - The Consulting Mechanical-Electrical Engineers either consulting to the Owners, Architect, other Engineers, etc. In this case: CMTA, Inc., Consulting Engineers.

(3) Architect - The Architect of Record for the project.

(4) Furnish - Deliver to the site in good condition and turn over to the Contractor who is to install.

(5) Provide - Furnish and install complete, tested and ready for operation.

(6) Install - Receive and place in satisfactory operation.

(7) Indicated - Listed in the Specifications, shown on the Drawings or Addenda thereto.

(8) Typical - Where indicated repeat this work, method or means each time the same or similar condition occurs whether indicated or not.

(9) Contract Documents - All documents pertinent to the quality and quantity of work to be performed on this project. Includes, but not limited to: Plans, Specifications, Instructions to Bidders, General and Special Conditions, Addenda, Alternates, Lists of Materials, Lists of Sub-Contractors, Unit Prices, Shop Drawings, Field Orders, Change Orders, Cost Breakdowns, Schedules of Value, Periodical Payment Requests, Construction Contract with Owners, etc.

(10) Proposer - Any person, agency or entity submitting a proposal to any person, agency or entity for any part of the work required under this contract.

(11) OSHA - Office of Safety and Health Administration.

(12) KBC - Kentucky Building Code.

(13) The Project - All of the work required under this Contract.

(14) NEC - National Electrical Code.

(16) ASME - American Society of Mechanical Engineers.

(17) AGA - American Gas Association.

(18) SMACNA - Sheet Metal and Air Conditioning Contractors National Association.


(20) ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers.

(21) NEMA - National Electrical Manufacturers Association.

(22) UL - Underwriters Laboratories.

(23) ADA - Americans with Disabilities Act.

(24) IMC - International Mechanical Code.


(26) IFGC - International Fuel Gas Code.

I. Required Notices:

(1) Ten days prior to the submission of a proposal, each proposer shall give written notice to the Engineer of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules or regulations of authorities having jurisdiction; and any necessary items of work omitted. In the absence of such written notice, Proposers signify that they have included the cost of all required items in the proposal and that the Proposer will be responsible for the safe and satisfactory operation of the entire system.

2. INTENT

A. It is the intention of the Contract Documents to call for finished work, tested and ready for operation.

B. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.

3. DRAWINGS AND SPECIFICATIONS

A. The drawings are diagrammatic only and indicate the general arrangement of the systems and are to be followed. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted to the Engineer for approval before
proceeding with the work. The drawings are not intended to show every item which may be necessary to complete the systems. All proposers shall anticipate that additional items may be required and submit their bid accordingly.

B. The drawings and specifications are intended to supplement each other. No Proposer shall take advantage of conflict between them, or between parts of either. Should this condition exist, the Proposer shall request a clarification not less than twelve days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be final.

C. The drawings and specifications shall be considered to be cooperative and anything appearing in the specifications which may not be indicated on the drawings or conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.

D. Contractor shall make all his own measurements in the field and shall be responsible for correct fitting. He shall coordinate this work with all other branches of work in such a manner as to cause a minimum of conflict or delay.

E. The Engineer shall reserve the right to make adjustments in location of piping, ductwork, equipment, etc. where such adjustments are in the interest of improving the project.

F. Should conflict or overlap (duplication) of work between the various trades become evident, this shall be called to the attention of the Engineer. In such event neither trade shall assume that he is to be relieved of the work which is specified under his branch until instructions in writing are received from the Engineer.

G. Unless dimensioned, the mechanical drawings only indicate approximate locations of equipment, piping, ductwork, etc. Dimensions given in figures on the drawings shall take precedence over scaled dimensions and all dimensions, whether given in figures or scaled, shall be verified in the field to ensure no conflict with other work.

H. Each Proposer shall review all drawings including Architectural, Mechanical, Electrical, Fire Protection, Landscaping, Structural, Surveys, etc., to ensure that the work he intends to provide does not encroach a conflict with or affect the work of others in any way. Where such effect does occur it shall be the Proposer's responsibility to satisfactorily eliminate any such encroachment conflict or effect prior to the submission of his proposal. Each Proposer shall in particular ensure that there is adequate space to install his equipment and materials. Failure to do so shall result in the correction of such encroachment conflict or effect of any work awarded the proposer and shall be accomplished fully without expense to others and that they are reasonably accessible for maintenance. Check closely all mechanical and electrical closets, chases, ceiling voids, wall voids, crawl spaces, etc., to ensure adequate spaces.

I. Where on the drawings a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornamentation or other detail is indicated by starting only, such detail shall be
continued throughout the courses or parts in which it occurs and shall also apply to all other
similar parts of the work, unless otherwise indicated.

J. Details not usually shown or specified, but necessary for the proper installation and operation of
systems, equipment, materials, etc., shall be included in the work, the same as if herein specified
or indicated.

K. Where on the Drawings or Addenda the word typical is used, it shall mean that the work method
or means indicated as typical shall be repeated in and each time it occurs whether indicated or
not.

L. Special Note: Always check ceiling heights indicated on Architectural Drawings and Schedules
and ensure that they may be maintained after all mechanical and electrical equipment is installed.
Do not install equipment in the affected area until the conflict is resolved.

4. EXAMINATION OF SITE AND CONDITIONS

A. Each Proposer shall inform himself of all of the conditions under which the work is to be
performed, the site of the work, the structure of the ground, above and below grade, the obstacles
that may be encountered, the availability and location of necessary facilities and all relevant
matters concerning the work. Each Proposer shall also fully acquaint himself with all existing
conditions as to ingress and egress, distance of haul from supply points, routes for transportation
of materials, facilities and services, availability of utilities, etc. His proposal shall cover all
expenses or disbursements in connection with such matters and conditions. No allowance will be
made for lack of knowledge concerning such conditions after bids are accepted.

5. EQUIPMENT AND MATERIALS SUBSTITUTIONS OR DEVIATIONS

A. When any Contractor requests approval of materials and/or equipment of different physical size,
capacity, function, color, access, it shall be understood that such substitution, if approved, will be
made without additional cost to anyone other than the Contractor requesting the change
regardless of changes in connections, space requirements, electrical characteristics, electrical
services, etc., from that indicated. In all cases where substitutions affect other trades, the
Contractor requesting such substitutions shall advise all such Contractors of the change and shall
remunerate them for all necessary changes in their work. Any drawings, Specifications,
Diagrams, etc., required to describe and coordinate such substitutions or deviations shall be
professionally prepared at the responsible Contractor's expense. Review of Shop Drawings by
the Engineers does not in any way absolve the Contractor of this responsibility.

B. Notwithstanding any reference in the specifications to any article, device, product, material,
fixture, form, or type of construction by name, make or catalog number, such reference shall be
interpreted as establishing a standard of quality and shall not be construed as limiting
competition; any devices, products, materials, fixtures, forms, or types of construction which, in
the judgment of the Engineer, are equivalent to those specified are acceptable, provided the
provisions of Paragraph (A) immediately preceding are met. Requested substitutions shall be
submitted to the Engineer a minimum of twelve days prior to bids.
C. Wherever any equipment and material is specified exclusively only such items shall be used unless substitution is accepted in writing by the Engineers.

D. Each Proposer shall furnish along with his proposal a list of specified equipment and materials which he is to provide. Where several makes are mentioned in the specifications and the Contractor fails to state which he proposes to furnish, the Engineer shall choose any of the makes mentioned without change in price. Inclusion in this list shall not ensure that the Engineers will approve shop drawings unless the equipment, materials, etc., submitted in shop drawings is satisfactorily comparable to the items specified and/or indicated.

6. SUPERVISION OF WORK

A. The Contractor shall personally supervise the work for which he is responsible or have a competent superintendent, approved by the Engineers, on the work at all times during progress with full authority to act for him.

7. CODES, RULES, PERMITS, FEES, INSPECTIONS, REGULATIONS, ETC.

A. The Contractor shall give all necessary notices, obtain and pay for all permits, government sales taxes, fees, inspections and other costs, including all utility connections, meters, meter settings, taps, tap fees, extensions, water and/or sewer system development charge, etc. in connection with his work. He shall also file all necessary plans, prepare all documents and obtain all necessary approvals of all governmental departments and/or the appropriate municipality or utility company having jurisdiction, whether indicated or specified or not. He shall hire an independent Registered Engineer to witness installations and provide necessary certifications where required by utility companies, municipal agencies or others that have review authority. He shall also obtain all required certificates of inspection for his work and deliver same to the Engineers before request for acceptance and final payment for the work. Ignorance of Codes, Rules, Regulations, Laws, etc. shall not render the Contractor irresponsible for compliance. The Contractor shall also be versed in all Codes, Rules and Regulations pertinent to his part of the work prior to submission of a proposal.

B. The Contractor shall include in his work, without extra cost, any labor, materials, services, apparatus and drawings in order to comply with all applicable laws, ordinances, rules and regulations, whether or not indicated or specified.

C. All materials furnished and all work installed shall comply with the National Fire Codes of the National Fire Protection Association, with the requirements of local utility companies, or municipalities and with the requirements of all governmental agencies having jurisdiction.

D. All materials and equipment so indicated and all equipment and materials for the electrical portion of the mechanical systems shall bear the approval label of, or shall be listed by the Underwriters' Laboratories (UL), Incorporated. Each packaged assembly shall be approved as a package. Approval of components of a package shall not be acceptable. Where required by the
Code and/or the Authority Having Jurisdiction, provide the services of a field labeling agency to provide a UL label for the entire system in the field under evaluation.

E. All plumbing work is to be constructed and installed in accordance with plans and specifications which have been approved in their entirety and/or reflect any changes requested by the State Department of Health. Plumbing work shall not commence until such plans are in the hands of the Contractor.

F. All Heating, Ventilation and Air Conditioning work shall be accomplished in accordance with the Kentucky Building Code (KBC) and amendments thereto, the latest standards recognized by the American Society of Heating, Refrigerating and Air Conditioning and the National Fire Protection Association. Contractor shall secure a permit from the Division of HVAC. Final inspection certificate shall be provided by Contractor and a copy included in Operation and Maintenance Manuals.

G. All pressure vessel installations shall comply with the State, and/or Federal Code applicable. A Certificate of Final Boiler Inspection shall be required.

H. The Contractor shall furnish three (3) copies of all Final Inspection Certificates obtained to the Engineer when work is complete. Final payment for work will be contingent upon compliance with this requirement.

I. Where minimum code requirements are exceeded in the Design, the Design shall govern.

J. The Contractor shall ensure that his work is accomplished in accord with the OSHA Standards and that he conducts his work and the work of his personnel in accord with same.

K. All work relating to the handicapped shall be in accord with regulations currently enforced by the Department of Housing, Buildings and Construction, Commonwealth of Kentucky and the American Disabilities Act.

L. All work in conjunction with a natural gas installation shall, in addition to all other Codes, Rules, Regulations, Standards, etc., comply with the requirements of the local gas supplier and/or standards and recommendations of the American Gas Association.

M. All work in relation to domestic water systems shall, in addition to all other Codes, Rules, Regulations and Standards, be in compliance with the requirements of the local water utility company and the adopted edition of the 10 States Standards.

N. All work in relation to the installation of sanitary or storm sewers shall, in addition to all other Codes, Rules, Regulations and Standards, be in compliance with the local agency governing such installations and the adopted edition of the 10 States Standards.

O. The Contractor shall provide the services of a qualified third party independent inspector to perform all required special inspections required by KBC, as follows:
(1) Smoke Control System as required by KBC 909.3.

(2) Mechanical and Electrical Component Seismic Bracing per KBC 1705.12.

8. EQUIPMENT AND PIPING SUPPORT

A. Each piece of equipment, apparatus, piping, or conduit suspended from the structure or mounted above the floor level shall be provided with suitable structural support, pipe stand, platform or carrier in accordance with the best recognized practice. Such supporting or mounting means shall be provided by the Contractor for all equipment and piping. Exercise extreme care that structural members of building are not overloaded by such equipment. Provide any required additional bracing, cross members, angles, support, etc., as indicated or required by the Structural Engineer. This, in some instances, will require the Contractor to add an angle to a joist to transfer the load to a panel point. If in doubt, contact the Structural Engineer.

9. DUCT AND PIPE MOUNTING HEIGHTS

A. All exposed or concealed ductwork, piping, etc., shall be held as high as possible unless otherwise noted and coordinated with all other trades. Exposed piping and ductwork shall, insofar as possible, run perpendicular or parallel to the building structure.

10. COST BREAKDOWNS (SCHEDULE OF VALUES)

A. Within thirty days after acceptance of the Contract, the Contractor shall furnish to the Engineer, one copy of a detailed cost breakdown on each respective area of work. These cost breakdowns shall be made in a format approved by the Engineer. Payments will not be made until satisfactory cost breakdowns are submitted.

11. CORRECTION PERIOD

A. All equipment, apparatus, materials, and workmanship shall be the best of its respective kind. The Contractor shall replace all parts at his own expense, which are proven defective as described in the General Conditions. The effective date of completion of the work shall be the date of the Architect's or Engineer's Statement of Substantial Completion. Items of equipment which have longer guarantees, as called for in these specifications, shall have warranties and guarantees completed in order, and shall be in effect at the time of final acceptance of the work by the Engineer. The Contractor shall present the Engineer with such warranties and guarantees at the time of final acceptance of the work. The Owner reserves the right to use equipment installed by the Contractor prior to date of final acceptance. Such use of equipment shall not invalidate the guarantee except that the Owner shall be liable for any damage to equipment during this period, due to negligence of his operator or other employees. Refer to other sections for any special or extra warranty requirements.

B. It is further clarified that all required and specified warranties shall begin on the date of Substantial Completion, not at the time of equipment start-up.
C. All gas fired heat exchangers shall have 20 year warranty.

D. All compressors shall have five year warranty.

12. COMPUTER-BASED SYSTEM SOFTWARE

A. For all equipment, controls, hardware, computer-based systems, programmable logic controllers, and other materials provided as a part of the work, software that is installed shall be certified in writing to the Engineer and Owner by the manufacturer and/or writer to be free of programming errors that might affect the functionality of the intended use.

13. CHANGES IN MECHANICAL WORK

REFER TO GENERAL AND SPECIAL CONDITIONS.

14. CLAIMS FOR EXTRA COST

REFER TO GENERAL AND SPECIAL CONDITIONS.

15. SURVEY, MEASUREMENTS AND GRADE

A. The Contractor shall lay out his work and be responsible for all necessary lines, levels, elevations and measurements. He must verify the figures shown on the drawings before laying out the work and will be held responsible for any error resulting from his failure to do so.

B. The Contractor shall base all measurements, both horizontal and vertical from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at the site and check the correctness of same as related to the work.

C. Should the Contractor discover any discrepancy between actual measurements and those indicated, which prevents following good practice or the intent of the contract documents, he shall promptly notify the Engineer and shall not proceed with this work until he has received instructions from the Engineer on the disposition of the work.

16. TEMPORARY USE OF EQUIPMENT

A. The permanent heating and plumbing equipment, when installed, may be used for temporary services, with the consent of the Engineers. Should the permanent systems be used for this purpose the Contractors shall make all temporary connections required at their expense. They shall also make any replacement required due to damage wear and tear, etc., leaving the same in "as new" condition.

B. Permission to use the permanent equipment does not relieve the Contractors from the responsibility for any damages to the building construction and/or equipment which might result because of its use.
C. A pre-start-up conference shall be held with the Architect, Owner, General Contractor and the Mechanical Contractor. Equipment shall not be started until after this meeting.

D. During all phases of construction:

(1) Air Handling Units:

a. At a minimum, four complete sets of filter media are required for each unit. In each unit, install two sets of filter media during construction (more shall be required if construction activities dictate more frequent changes). In each unit, install one set of filter media at substantial completion. Leave one set of filter media in boxes in appropriate mechanical room as a spare set for the Owner. All other filters shall be used by the Contractor during construction. Dispose of all construction filter media.

b. On the outside of all return air openings install a minimum of two sets of fiberglass filter media, such as cheesecloth, to be utilized as pre-filters for the “construction” filters. Install first set upon start-up and then install second set when first set is dirty. Dispose of all dirty construction filters. Change filters as often as necessary to keep units from becoming dirty at no additional cost.

c. At substantial completion of the project the entire unit shall be cleaned to present a like “new” unit for the Owner and all filters shall be replaced with new.

(2) Heat Pump Units:

a. At a minimum, four complete sets of filter media are required for each unit. In each unit, install two sets of filter media during construction (more shall be required if construction activities dictate more frequent changes). In each unit, install one set of filter media at substantial completion. Leave one set of filter media in boxes in appropriate mechanical room as a spare set for the Owner. All other filters shall be used by the Contractor during construction. Dispose of all construction filter media.

b. On the outside of all return air openings install a minimum of two sets of fiberglass filter media, such as cheesecloth, to be utilized as pre-filters for the “construction” filters. Install first set upon start-up and then install second set when first set is dirty. Dispose of all dirty construction filters. Change filters as often as necessary to keep units from becoming dirty at no additional cost.

c. At substantial completion of the project the entire unit shall be cleaned to present a like “new” unit for the Owner and all filters shall be replaced with new.

(3) Outside Air Units:

a. These units shall not be used for temporary heating and cooling by the Contractor. They shall, however, be made operational, tested, etc. as specified during construction by the Contractor. Three complete sets of filters are required for each unit. In each unit, install one set of filters during construction. In each unit, install one set of filters at substantial completion. For each unit, leave third set of filters in boxes in appropriate mechanical
room as a spare set for the Owner. Dispose of all construction filters.

b. At substantial completion of the project the entire unit shall be cleaned to present a like “new” unit for the Owner and all filters shall be replaced with new.

E. The contractor shall be allowed to use the above mentioned units and its associated ductwork provided the following conditions are met:

1. The return air ductwork main shall be disconnected above the ceiling to utilize the space above the ceiling as a plenum. This shall prevent the return air ductwork from being used.

2. Four sets of fiberglass filter media shall be installed at all of the inlets of each air handling unit. A differential pressure gauge shall be installed and the filter media shall be changed whenever a 1.0” wg pressure differential is present across the filter media. This shall be reviewed and recorded weekly by the contractor. The contractor is responsible for any temporary duct modifications as required to install the filter media.

3. The 90% final filters shall be installed prior to the start-up of the air handling units. These shall be replaced whenever a 1.25” wg pressure differential is present. This shall be reviewed and recorded weekly.

4. The contractor shall replace all filter media with new and connect all ductwork to the units prior to the start of balancing any duct systems.

5. Upon completion of the project the entire unit shall be cleaned to present a like “new” unit for the owner and all filters shall be replaced with new.

17. TEMPORARY SERVICES

A. The Contractor shall arrange any temporary water, electrical and other services which he may require to accomplish his work. Refer also to General and Special Conditions.

18. RECORD DRAWINGS

A. The Contractor shall ensure that any deviations from the Design are as they occur recorded in red, erasable pencil on record drawings kept at the jobsite. The Engineer shall review the record documents from time to time to ensure compliance with this specification. Compliance shall be a contingency of final payment. Pay particular attention to the location of under floor sanitary and water lines, shut-off valves, cleanouts and other appurtenances important to the maintenance and operation of Mechanical Systems. Also, pay particular attention to Deviations in the Control Systems and all exterior utilities. Keep information in a set of drawings set aside at the job site especially for this purpose. Deliver these record drawings electronically in AutoCAD 2000 format along with the hand marked field set to the Engineer. Electronic bid drawings will be furnished to the Contractor for his use.

19. MATERIALS AND WORKMANSHIP
A. All equipment, materials and articles incorporated in the work shall be new and of comparable quality to that specified. Each Proposer shall determine that the materials and/or equipment he proposes to furnish can be brought into the building(s) and installed within the space available. In certain cases, it may be necessary to remove and replace walls, floors and/or ceilings and this work shall be the responsibility of the Contractor. All equipment shall be installed so that all parts are readily accessible for inspection, maintenance, replacement of filters, etc. Extra compensation will not be allowed for relocation of equipment for accessibility or for dismantling equipment to obtain entrance into the building(s). Ensure, through coordination, that no other Contractor seals off access to space required for equipment, materials, etc.

B. Materials and equipment, where applicable, shall bear Underwriters' Laboratories label where such a standard has been established.

C. Use extreme care in the selection of equipment and its installation to ensure that noise and vibration are kept at a minimum. The Engineer's determination shall be final and corrections to such discrepancies shall be made at the cost of the Contractor.

D. Each length of pipe, fitting, trap, fixture and device used in the plumbing or drainage systems shall be stamped or indelibly marked with the weight or quality thereof and with the manufacturer's mark or name.

E. All equipment shall bear the manufacturer's name and address. All electrically operated equipment shall bear a data plate indicating required horsepower, voltage, phase and ampacity.

20. COOPERATION AND COORDINATION WITH OTHER TRADES

A. The Contractor shall give full cooperation to all other trades and shall furnish in writing with copies to the Engineer, any information necessary to permit the work of other trades to be installed satisfactorily and with the least possible interference or delay.

B. Where any work is to be installed in close proximity to, or will interfere with work of other trades, each shall cooperate in working out space conditions to make a satisfactory adjustment. If so directed by the Engineer, the Contractor shall prepare composite working drawings and sections at a suitable scale not less than 1/4” = 1'-0”, clearly indicating how his work is to be installed in relation to the work of other trades, or so as not to cause any interference with work of other trades. He shall make the necessary changes in his work to correct the condition without extra charge.

C. The Contractor shall furnish to other trades, as required, all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

21. QUALIFICATIONS OF WORKMEN

A. All mechanical work shall be accomplished by qualified workmen competent in the area of work for which they are responsible. Untrained and incompetent workmen, as evidenced by their
workmanship, shall be summarily relieved of their responsibilities in areas of incompetency. The
Engineer shall reserve the right to determine the quality of workmanship of any workman and
unqualified or incompetent workman shall refrain from work in areas not satisfactory to him.
Requests for relief of a workman shall be made through the normal channels of Architect, Contractor, etc.

B. All plumbing work shall be accomplished by Journeymen Plumbers under the direct supervision
of a Master Plumber as defined and clarified under Kentucky State Plumbing Law Regulations
and Code. Proof and Certification may be requested by the Engineer.

C. All sheet metal, insulation and pipe fitting work shall be installed by workmen normally engaged
or employed in these respective trades, except where only small amounts of such work are
required and are within the competency of workmen directly employed by the Contractor
involved.

D. All automatic control systems shall be installed by workmen normally engaged or employed in
this type work, except in the case of minor control requirements (residential type furnaces,
packaged HVAC equipment with integral controls, etc.) in which case, if a competent workman
is the employee of this Contractor, he may be utilized subject to review of his qualifications by
the Engineer and after written approval from same.

E. All special systems (Automatic Sprinkler Equipment.) shall be installed only by workmen
normally engaged in such services. Exception to this specification may only be made in writing
by the Engineer.

F. All electrical work shall be installed only by competent workmen under direct supervision of a
fully qualified Electrician.

22. CONDUCT OF WORKMEN

A. The Contractor shall be responsible for the conduct of all workmen under his supervision.
Misconduct on the part of any workman to the extent of creating a safety hazard, or endangering
the lives and property of others, shall result in the prompt relief of that workman. The
consumption of alcoholic beverages or other intoxicants, narcotics, barbiturates, hallucinogens or
debilitating drugs on the job site is strictly forbidden.

23. PROTECTION OF MATERIALS AND EQUIPMENT

A. The Contractor shall be entirely responsible for all material and equipment furnished by him in
connection with his work and special care shall be taken to properly protect all parts thereof from
physical, sun, and weather damage during the construction period. Such protection shall be by a
means acceptable to the manufacturer and Engineer. All rough-in soil, waste, vent and storm
piping, ductwork, etc., shall be properly plugged or capped during construction in a manner
approved by the Engineer. Equipment damaged, stolen or vandalized while stored on site, either
before or after installation, shall be repaired or replaced by the Contractor at his own expense.
24. SCAFFOLDING, RIGGING AND HOISTING

A. The Contractor shall furnish all scaffolding, rigging, hoisting and services necessary for erection and delivery onto the premises of any equipment and apparatus furnished. All such temporary appurtenances shall be set up in strict accord with OSHA Standards and Requirements. Remove same from premises when no longer required.

25. BROKEN LINES AND PROTECTION AGAINST FREEZING

A. No conduits, piping, troughs, etc. carrying water or any other fluid subject to freezing shall be installed in any part of the building where danger of freezing may exist without adequate protection being given by the Contractor whether or not insulation is specified or indicated on the particular piping. All damages resulting from broken and/or leaking lines shall be replaced or repaired at the Contractor's own expense. If in doubt, contact the Engineer. Do not install piping across or near openings to the outside whether they are carrying static or moving fluids or not. Special Note: Insulation on piping does not necessarily ensure that freezing will not occur.

26. CLEANING

A. The Contractor shall, at all times, keep the area of his work presentable to the public and clean of rubbish and debris caused by his operations; and at the completion of the work, shall remove all rubbish, debris, all of his tools, equipment, temporary work and surplus materials from and about the premises, and shall leave the area clean and ready for use. If the Contractor does not attend to such cleaning upon request, the Engineer may cause cleaning to be done by others and charge the cost of same to the Contractor. The Contractor shall be responsible for all damage from fire which originates in, or is propagated by, accumulations of his rubbish or debris.

B. After completion of all work and before final acceptance of the work, the Contractor shall thoroughly clean all equipment and materials and shall remove all foreign matter such as grease, dirt, plaster, labels, stickers, etc., from the exterior of piping, equipment, fixtures and all other associated or adjacent fabrication.

27. CONCRETE WORK

A. The Contractor shall be finally responsible for the provisions of all concrete work required for the installation of any of his systems or equipment. He may, at his option, arrange with the others to provide the work. This option, however, will not relieve the Contractor of his responsibilities relative to dimensions, quality of workmanship, locations, etc. In the absence of other concrete specifications, all concrete related to Mechanical work shall be 3000 psi minimum compression strength at 28 days curing and shall conform to the standards of the American Concrete Institute Publication ACI-318. Heavy equipment shall not be set on pads for at least seven (7) days after pour. Insert 6-inch steel dowel rods into floors to anchor pads.

B. All mechanical equipment (tanks, heaters, chillers, boilers, pumps, air handling units, etc.) shall be set on a minimum of 4” tall concrete pads. Pads shall be taller where required for condensate traps. All concrete pads shall be complete with all pipe sleeves, anchor bolts, reinforcing steel,
concrete, etc. as required. Pads larger than 18” in width shall be reinforced with ½” round bars on 6” centers both ways. Bars shall be approximately 3” above the bottom of the pad. All parts of pads and foundations shall be properly rodded or vibrated. If exposed parts of the pads and foundations are rough or show honeycomb after removing forms, all surfaces shall be rubbed to a smooth surface. Chamfer all square edges one-half inch.

C. In general, concrete pads for equipment shall extend four (4) inches beyond the equipment's base dimensions. Where necessary, extend pads 30 inches beyond base or overall dimensions to allow walking and servicing space.

D. Exterior concrete pads shall be four (4) inches minimum above grade and four (4) inches below grade on a tamped four (4) inch dense grade rock base unless otherwise indicated or specified. Surfaces of all foundations and bases shall have a smooth finish with one-half (1/2) inch chamfer on exposed edges.

E. All exterior below grade concrete structures (utility vaults, grease traps, manholes, etc.) shall be provided with exterior waterproofing. Waterproofing shall be hot-fluid applied rubberized-asphalt waterproofing membrane with elastomeric sheets at edges, corners, and terminations of membrane for continuous watertight construction. Apply in layers and reinforce as required to provide uniform seamless membrane minimum 4mm thickness. Also, seal all penetrations into and out of the structure watertight. Provide Link-Seal modular seal or equal.

28. NOISE, VIBRATION OR OSCILLATION

A. All work shall operate under all conditions of load without any sound or vibration which is objectionable in the opinion of the Engineer. In case of moving machinery, sound or vibration noticeable outside of room in which it is installed, or annoyingly noticeable inside its own room, will be considered objectionable. Sound or vibration conditions considered objectionable by the Engineer shall be corrected in an approved manner by the Contractor at his expense.

B. All equipment subject to vibration and/or oscillation shall be mounted on vibration supports whether indicated or not suitable for the purpose of minimizing noise and vibration transmission, and shall be isolated from external connections such as piping, ducts, etc. by means of flexible connectors, vibration absorbers, or other approved means. Unitary equipment, such as small room heating units, small exhaust fans, etc., shall be rigidly braced and mounted to wall, floor or ceiling as required and tightly gasketed and sealed to mounting surface to prevent air leakage and to obtain quiet operation. Flush and surface mounted equipment such as diffusers, grilles, etc., shall be gasketed and affixed tightly to their mounting surface.

C. The Contractor shall provide supports for all equipment furnished by him. Supports shall be liberally sized and adequate to carry the load of the equipment and the loads of attached equipment, piping, etc. All equipment shall be securely fastened to the structure either directly or indirectly through supporting members by means of bolts or equally effective means. If strength of supporting structural members is questionable, contact Engineers.

29. ACCESSIBILITY

GENERAL PROVISIONS
A. The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate clearance in double partitions and hung ceilings for the proper installation of his work. He shall cooperate with all others whose work is in the same space. Such spaces and clearances shall, however, be kept to the minimum size required.

B. The Contractor shall locate and install all equipment so that it may be serviced, and maintained as recommended by the manufacturer. Allow ready access and removal of the entire unit and/or parts such as valves, filters, fan belts, motors, prime shafts, etc.

C. The Contractor shall provide access panels for each concealed valve, control damper or other device requiring service as shown on engineer's plans or as required. Locations of these panels shall be identified in sufficient time to be installed in the normal course of work.

30. RESTORATION OF NEW OR EXISTING SHRUBS, PAVING, SURFACES, ETC.

A. The Contractor shall at his expense restore to their original conditions all paving, curbing, surfaces, drainage ditches, structures, fences, shrubs, existing or new building surfaces and appurtenances, and any other items damaged or removed by his operations. Replacement and repairs shall be in accordance with good construction practice and shall match materials employed in the original construction of the item and shall be to the satisfaction of the Architect and/or Engineer.

31. MAINTENANCE OF EXISTING UTILITIES AND LINES

A. The locations of all piping, conduits, cables, utilities and manholes existing, or otherwise, that comes within the contract construction site, shall be subject to continuous uninterrupted service with no other exception than the Owner of the utilities permission to interrupt same temporarily.

B. Utilities and lines, where known, are indicated on the drawings. Locations and sizes are approximate. Prior to any excavation being performed, the Contractor shall ascertain that no utilities or lines are endangered by new excavation. Exercise extreme caution in all excavation work.

C. If utilities or lines occur in the earth within the construction site, the Contractor shall probe and locate the lines prior to machine excavation or blasting in the respective area. Electromagnetic utility locators and acoustic pipe locators shall be utilized to determine where metallic and non-metallic piping is buried prior to any excavation.

D. Cutting into existing utilities and services where required shall be done in coordination with and only at times designated by the Owner of the utility.

E. The Contractor shall repair to the satisfaction of the Engineer, any surfaces or subsurface improvements damaged during the course of the work, unless such improvement is shown to be abandoned or removed.
F. Machine excavation shall not be permitted with ten feet of electrical lines or lines carrying combustible and/or explosive materials. Hand excavate only.

G. Protect all new or existing lines from damage by traffic, etc. during construction. Repairs or replacement of such damage shall be at the sole expense of the party responsible.

32. SMOKE AND FIRE PROOFING

A. The Contractor shall fire and smoke stop all openings made in fire or smoke rated walls, chases, ceilings and floors in accord with the KBC. Patch all openings around ductwork and piping with appropriate type material to stop smoke at smoke walls and provide commensurate fire rating at fire walls, floors, ceilings, roofs, etc. Back boxes in rated walls shall be a minimum distance apart as allowed by code to maintain the rating. If closer provide rated box or fireproofing in code approved manner.

33. MOTORS

A. Motors shall be built in accordance with the latest standards of NEMA and as specified. Motors shall be tested in accordance with standards of A.S.A. C50, conforming to this and all applicable standards for insulation resistance and dielectric strength.

B. Each motor shall be provided by the equipment supplier, installer or manufacturer with conduit terminal box, and N.E.C. required disconnecting means as specified or required. Three-phase motors shall be provided with external thermal overload protection in their starter units. Single-phase motors shall be provided with thermal overload protection, integral to their windings or external, in control unit. All motors shall be installed with NEMA-rated starters as specified and shall be connected per the National Electrical Code.

C. The capacity of each motor shall be sufficient to operate associated driven devices under all conditions of operation and load and without overload, and at least of the horsepower indicated or specified. Each motor shall be selected for quiet operation, maximum efficiency and lowest starting KVA per horsepower. Motors producing excessive noise or vibration shall be replaced by the responsible contractor. See Division 16 of Specifications for further requirements related to installation of motors.

34. CUTTING AND PATCHING

A. The Contractor shall provide his own cutting and patching necessary to install his work. Patching shall match adjacent surfaces and shall be to the satisfaction of the Architect and Engineer.

B. No structural members shall be cut without the approval of the Engineer and all such cutting shall be done in a manner directed by him.
C. When installing conduit, pipe, or any other work in insulated concrete form (ICF) walls, the responsible subcontractor for the work shall provide spray foam insulation to patch the rigid insulation to maintain full integrity of the insulating value of the wall after the mechanical and electrical work is complete. Furthermore all new work shall NOT be installed in concrete center of wall. All mechanical and electrical installations shall be on the interior side of the concrete.

35. CURBS, PLATES, ESCUTCHEONS & AIR TIGHT PENETRATIONS

A. In all areas where ducts are exposed and ducts pass thru floors, the opening shall be surrounded by a 4 inch high by 3 inch wide concrete curb.

B. Escutcheon plates shall be provided for all pipes and conduit passing thru walls, floors and ceilings. Plates shall be nickel plated, of the split ring type, of size to match the pipe or conduit. Where plates are provided for pipes passing thru sleeves which extend above the floor surface, provide deep recessed plates to conceal the pipe sleeves.

C. Seal all duct, pipe, conduit, etc., penetrations through walls and floors air tight. If wall or floor assembly is rated then use similarly rated sealing method.

36. WEATHERPROOFING

A. Where any work pierces waterproofing including waterproof concrete, the method of installation shall be as approved by the Engineer before work is done. The Contractor shall furnish all necessary sleeves, caulking and flashing required to make openings permanently watertight.

37. OPERATING INSTRUCTIONS, MAINTENANCE MANUALS AND PARTS LISTS

A. Upon completion of all work tests, the Contractor shall instruct the Owner or his representative(s) fully in the operations, adjustment and maintenance of all equipment furnished. The time and a list of representatives required to be present will be as directed by the Engineer. Turn over all special wrenches, keys, etc., to the owner at this time.

B. The Contractor shall furnish three (3) complete bound sets for delivery to the Engineer of typewritten and/or blueprinted instructions for operating and maintaining all systems and equipment included in this contract prior to substantial completion. All instructions shall be submitted in draft, for approval, prior to final issue. Manufacturer's advertising literature or catalogs alone will not be acceptable for operating and maintenance instructions.

C. The Contractor, in the instructions, shall include a preventive maintenance schedule for the principal items of equipment furnished under this contract and a detailed, parts list and the name and address of the nearest source of supply.

D. The Contractor shall frame under Lexan in the main mechanical room all temperature control diagrams and all piping diagrams.

38. PAINTING
A. In general, all finish painting shall be accomplished under the Painting Section of the specifications by the Contractor; however, unless otherwise specified under other sections of these specifications, the following items shall be painted:

(1) All exposed piping, valve bodies and fittings (bare and insulated), including hangers, platforms, etc.

(2) All mechanical equipment not factory finished. Aluminum and stainless steel equipment, motors, identification plates, tags, etc. shall not be painted. All rust and foreign matter shall be thoroughly removed from surfaces prior to painting. All baked enamel factory finish of equipment which may have been scratched or chipped shall be touched up with the proper paint as recommended and supplied by the manufacturer.

(3) All ductwork exposed in finished areas (bare and insulated), all grilles, diffusers, etc. not factory finished. Paint the inside surfaces of all interior duct surfaces visible from any register, grille or diffuser opening on all jobs; surfaces shall receive one (1) prime coat of Rustoleum 1225 red "galvinoleum" or other approved equivalent primer and rust inhibitor and one (1) coat of Rustoleum 1579 jet black "Speedy Dry" enamel or approved equivalent applied in accordance with the manufacturer's recommendations.

(4) All insulated piping, ductwork and equipment shall be properly prepared for painting by the Contractor where mechanical items are to be painted. In the case of externally insulated duct and pipe, the Contractor shall provide 6 oz. canvas jacket with fire retardant lagging. The jacket shall be allowed to dry properly before applying paint to avoid shrinking after painting and exposing unpainted surfaces. The Contractor, at his option, may provide double wall ductwork in lieu of externally insulated ductwork with canvas jacket and lagging.

39. ELECTRICAL CONNECTIONS

A. The Contractor shall furnish and install all (1) temperature control wiring; (2) equipment control wiring and (3) interlock wiring. The Contractor shall furnish and install all power wiring complete from power source to motor or equipment junction box, including power wiring thru starters, and shall furnish and install all required starters not factory mounted on equipment.

B. The Contractor shall, regardless of voltage, furnish and install all temperature control wiring and all associated interlock wiring, all equipment control wiring and conduit for the equipment that the Contractor furnishes. He may, at his option, employ at his own expense, the Electrical Contractor to accomplish this work.

C. After all circuits are energized and completed, the Contractor shall be responsible for all power wiring, and all control wiring shall be the responsibility of the Contractor. Motors and equipment shall be provided for current characteristics as shown on the drawings.
D. The Contractor shall furnish motor starters of the type and size required by the manufacturer for all equipment provided by him, where such starters are necessary. Starters shall have overloads for each phase.

40. FINAL CONNECTIONS TO EQUIPMENT

A. The Contractor shall finally connect to mechanical services, any terminal equipment, appliances, etc., provided under this and other divisions of the work. Such connections shall be made in strict accord with current codes, safety regulations and the equipment manufacturers recommendations. If in doubt, contact the Engineers prior to installation.

41. REQUIRED CLEARANCE FOR ELECTRICAL EQUIPMENT

A. The NEC has specific required clearances above, in front, and around electrical gear, panels etc. The Contractor shall not install any piping, ductwork, etc., in the required clearance. If any appurtenance is located in the NEC required clearance, it shall be relocated at no additional cost.

42. INDEMNIFICATION

A. The Contractor shall hold harmless and indemnify the Engineer, employees, officers, agents and consultants from all claims, loss, damage, actions, causes of actions, expense and/or liability resulting from, brought for, or on account of any personal injury or property damage received or sustained by any person, persons, (including third parties), or any property growing out of, occurring, or attributable to any work performed under or related to this contract, resulting in whole or in part from the negligence of the Contractor, any subcontractor, any employee, agent or representative.

43. HAZARDOUS MATERIALS

A. The Contractor is hereby advised that it is possible that asbestos and/or other hazardous materials are or were present in this building(s). Any worker, occupant, visitor, inspector, etc., who encounters any material of whose content they are not certain shall promptly report the existence and location of that material to the Contractor and/or Owner. The Contractor shall, as a part of his work, ensure that his workers are aware of this potential and what they are to do in the event of suspicion. He shall also keep uninformed persons from the premises during construction. Furthermore, the Contractor shall ensure that no one comes near to or in contact with any such material or fumes therefrom until its content can be ascertained to be non-hazardous.

B. CMTA, Inc., Consulting Engineers, have no expertise in the determination of the presence of hazardous materials. Therefore, no attempt has been made by them to identify the existence or location of any such material. Furthermore, CMTA nor any affiliate thereof will neither offer nor make any recommendations relative to the removal, handling or disposal of such material.

C. If the work interfaces, connects or relates in any way with or to existing components which contain or bear any hazardous material, asbestos being one, then, it shall be the Contractor's sole responsibility to contact the Owner and so advise him immediately.
D. The Contractor by execution of the contract for any work and/or by the accomplishment of any work thereby agrees to bring no claim relative to hazardous materials for negligence, breach of contract, indemnity, or any other such item against CMTA, its principals, employees, agents or consultants. Also, the Contractor further agrees to defend, indemnify and hold CMTA, its principals, employees, agents and consultants, harmless from any such related claims which may be brought by any subcontractors, suppliers or any other third parties.

44. ABOVE-CEILING AND FINAL PUNCH LISTS

A. The Contractor shall review each area and prepare a punch list for each of the subcontractors, as applicable, for at least two stages of the project:

   (1) For review of above-ceiling work that will be concealed by tile or other materials well before substantial completion.

   (2) For review of all other work as the project nears substantial completion.

B. When all work from the Contractor's punch list is complete at each of these stages and prior to completing ceiling installations (or at the final punch list stage), the Contractor shall request that the Engineer develop a punch list. This request is to be made in writing seven days prior to the proposed date. After all corrections have been made from the Engineer's punch list, the Contractor shall review and initial off on each item. This signed-off punch list shall be submitted to the Engineer. The Engineer shall return to the site once to review each punch list and all work prior to the ceilings being installed and at the final punch list review.

C. If additional visits are required by the Engineer to review work not completed by this review, the Engineer shall be reimbursed directly by the Contractor at a rate of $140.00 per hour for extra trips required to complete either of the above-ceiling or final punch lists.

END OF SECTION 15000
SECTION 15010- SCOPE OF THE MECHANICAL WORK

1. GENERAL

A. The Mechanical work for this Contract shall include all labor, materials, equipment, fixtures, excavation, backfill and related items required to completely install, test, place in service and deliver to the Owner the complete mechanical systems in accordance with the accompanying plans and all provisions of these specifications. This work shall primarily include, but is not necessarily limited to the following:

(1) Complete exterior domestic water service finally connected to the local domestic water system.

(2) Complete exterior sanitary sewer system connected to the local system.

(3) Complete exterior storm drainage system.

(4) Complete exterior fire protection system.

(5) Interior domestic hot, cold and recirculating hot water system.

(6) Interior soil, waste and vent systems.

(7) Roof drainage system.

(8) All plumbing equipment, fixtures and fittings.

(9) 100% automatic sprinkler system.

(10) All mechanical exhaust systems.

(11) All insulation associated with mechanical systems.

(12) Condensate drainage systems.

(13) Complete heating, ventilation and air conditioning systems.

(14) Complete radiant heated flooring system.

(15) Final connection of all mechanical equipment furnished by others (e.g., kitchen equipment).

(16) Complete balancing of air and water systems.

(17) Complete natural gas piping systems.
(18) All applicable services and work specified in Section 15000; General Provisions - Mechanical.

(19) All specified or required control work.

(20) Provide all required motor starters, etc. not provided under the electrical sections.

(21) One year guarantee of all mechanical equipment, materials and workmanship.

(22) Thorough instruction of the owner’s maintenance personnel in the operation and maintenance of all mechanical equipment.

(23) Thorough coordination of the installation of all piping, equipment and any other material with other trades to ensure that no conflict in installation.

(24) Approved supervision of the mechanical work.

(25) Excavation, backfilling, cutting, patching, sleeving, concrete work, etc., required to construct the mechanical systems.

(26) Prior to submitting a bid, the Contractor shall contact all serving utility companies to determine exactly what each utility company will provide and exactly what is required of the Contractor and shall include such requirements in his base bid.

(27) Procurement of all required permits and inspections, including fees for all permits and inspection services and submission of final certificates of inspection to the Engineers (Plumbing, Boiler, HVAC, etc.).

(28) All necessary coordination with gas, water, and sewer utility companies, etc., to ensure that work, connections, etc., that they are to provide is accomplished.

(29) Factory start-up of all major equipment (including terminal HVAC equipment) and submission of associated factory start-up reports to the Engineer.

END OF SECTION 15010
SECTION 15020 - SHOP DRAWINGS, DESCRIPTIVE LITERATURE, MAINTENANCE MANUALS, PARTS LISTS, SPECIAL KEYS AND TOOLS

1. GENERAL

A. The Contractor's attention is directed also to the General and Special Conditions and Section 15000 - General Provisions - Mechanical as well as to all other Contract Documents as they may apply to his work.

B. The Contractor shall prepare and submit to the Engineer, through the General Contractor and the Architect (where applicable) within thirty (30) days after the date of the Contract, a minimum of seven (7) copies of all shop drawings, certified equipment drawings, installation, operating and maintenance instructions, samples, wiring diagrams, etc. on all items of equipment specified hereinafter.

C. Submittal data shall include specification data including metal gauges, finishes, accessories, etc. Also, the submittal data shall include certified performance data, wiring diagrams, dimensional data, and a spare parts list. Submittal data shall be reviewed by the Engineer before any equipment or materials is ordered or any work is begun in the area requiring the equipment.

D. All submittal data shall have the stamp of approval of the Contractor submitting the data as well as the General Contractor and the Architect (if applicable) to show that the drawings have been reviewed by the Contractor. Any drawings submitted without these stamps of approval may not be considered and will be returned for proper resubmission.

E. It shall be noted that review of shop drawings by the Engineer applies only to conformance with the design concept of the project and general compliance with the information given in the contract documents. In all cases, the Contractor alone shall be responsible for furnishing the proper quantity of equipment and/or materials required, for seeing that all equipment fits the available space in a satisfactory manner and that piping, electrical and all other connections are suitably located.

F. The Engineers' review of shop drawings, schedules or other required submittal data shall not relieve the Contractor from responsibility for: adaptability of the item to the project; compliance with applicable codes, rules, regulations and information that pertains to fabrication and installation; dimensions and quantities; electrical characteristics; and coordination of the work with all other trades involved in this project. Any items that differ from the Drawings or Specifications shall be flagged by the Contractor so the Engineer will be sure to see the item. Do not rely on the Engineer to “catch” items that do not comply with the Drawings or Specifications. The Contractor is responsible for meeting the Drawings and Specification requirements, regardless of whether or not something does not get caught by the Contractor or Engineer during shop drawing reviews.

G. Equipment shall not be ordered and no final rough-in connections, etc., shall be accomplished until reviewed equipment shop drawings are in the hands of the Contractor. It shall be the Contractor's responsibility to obtain reviewed shop drawings and to make all connections, etc. in

SHOP DRAWINGS

15020-1
the neatest and most workmanlike manner possible. The Contractor shall coordinate with all the other trades having any connections, roughing-in, etc. to the equipment.

H. If the Contractor fails to comply with the requirements set forth above, the Engineer shall have the option of selecting any or all items listed in the Specifications or on the drawings; and the Contractor shall be required to furnish all materials in accordance with this list.

I. Colors for equipment in other than mechanical spaces shall be selected from the Manufacturer's standard and factory optional colors. Color samples shall be furnished with the shop drawing submission for such equipment.

J. Shop Drawing Submittals

(1) All submittals for HVAC equipment shall include all information specified. This shall include air and water pressure drops, RPM, noise data, face velocities, horsepower, voltage motor type, steel or aluminum construction, and all accessories clearly marked.

(2) All items listed in the schedules shall be submitted for review in a tabular form similar to the equipment schedule.

(3) All items submitted shall be designated with the same identifying tag as specified on each sheet.

(4) Any submittals received in an unorganized manner without options listed and with incomplete data will be returned for resubmittal.

2. SHOP DRAWINGS

Shop Drawings, descriptive literature, technical data and required schedules shall be submitted on the following:

- Duct Insulation (Internal and External)
- Pipe Insulation
- Hydronic Specialties
- (2) Chemical Treatment System
- (1) Pumps and Circulators (HVAC)

SPECIAL NOTES:

1) Upon substantial completion of the project, the Contractor shall deliver to the Engineers (in addition to the required Shop Drawings) three (3) complete copies of operation and maintenance instructions and parts lists for each item marked (1) above. These documents shall include at least:

   a. Detailed operating instructions
   b. Detailed maintenance instructions including preventive maintenance schedules.
c. Addresses and phone numbers indicating where parts may be purchased.

2) Shop drawings for the Control Systems shall include detailed, scaled plans and schematic diagrams indicating the function and operation of the system.

3) Shop drawings for the Building Fire Protection System shall be prepared and stamped by a Certified Contractor and shall meet the criteria of the Department of Housing, Buildings and Construction and submitted to the Engineer. After the Engineer's review, they shall be submitted by the Contractor to the proper state authorities along with the required State review fee.

4) The Contractor shall submit to the Boiler Inspector's Office the required documentation and review fees for a boiler permit. The boiler permit shall be submitted to the Engineer along with the Boiler Shop Drawings.

5) The Contractor shall submit shop drawings for the kitchen hood system(s) along with all required supporting documentation and review fees to the Department of Housing, Buildings and Construction and receive approval prior to submittal to the Engineers.

6) The Contractor shall submit Material Safety Data sheets for all chemical treatment and anti-freeze solutions.

3. SPECIAL WRENCHES, TOOLS, ETC.

   (1) The Contractor shall furnish, along with equipment provided, any special wrenches or tools necessary to dismantle or service equipment or appliances installed under the Contract. Wrenches shall include necessary keys, handles and operators for valves, cocks, hydrants, etc. A reasonable number of each shall be furnished.

4. BALANCE REPORTS

   A. Upon substantial completion of the project, the Contractor shall submit to the Engineers four (4) bound copies of the Certified Air and Hydronic Balance Report.
SECTION 15030 - SLEEVING, CUTTING, PATCHING AND REPAIRING

1. GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, General Conditions-Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.

B. The Contractor shall be responsible for all openings, sleeves, trenches, etc., that he may require in floors, roofs, ceilings, walls, etc., and shall coordinate all such work with the General Contractor and all other trades. Coordinate with the General Contractor, any openings which he is to provide before submitting a bid proposal in order to avoid conflict and disagreement during construction. Improperly located openings shall be reworked at the expense of the Contractor.

C. The Contractor shall plan his work ahead and shall place sleeves, frames or forms through all walls, floors and ceilings during the initial construction, where it is necessary for piping, ductwork, conduit, etc., to go through; however, when this is not done, the Contractor shall do all cutting and patching required for the installation of his work, or he shall pay other trades for doing this work when so directed by the Engineer. Any damage caused to the buildings by the workmen of the responsible Contractor must be corrected or rectified by him at his own expense.

D. The Contractor shall notify other trades in due time where he will require openings or chases in new concrete or masonry. He shall set all concrete inserts and sleeves for his work. Failing to do this, he shall cut openings for his work and patch same as required at his own expense.

E. The Contractor shall be responsible for properly shoring, bracing, supporting, etc., any existing and/or new construction to guard against cracking, settling, collapsing, displacing or weakening while openings are being made. Any damage occurring to the existing and/or new structures, due to failure to exercise proper precautions or due to action of the elements shall be promptly and properly made good to the satisfaction of the Engineer.

F. All work improperly done or not done at all as required by the Mechanical Trades in this section, will be performed by the Contractor at the direction of the trade whose work is affected.

2. SLEEVES, PLATES AND ESCUTCHEONS

A. The Contractor shall provide and locate all sleeves and inserts required for his work before the floors and surface being penetrated are built, otherwise the Contractor shall core drill for pipes where sleeves and inserts were not installed, or where incorrectly located. Core drilling is the only acceptable alternative to sleeves. Do not chisel openings. Where sleeves are placed in exterior walls or in slabs on grade, the space between the pipe or conduit and the sleeves shall be made completely and permanently water tight.

B. Pipe that penetrates fire and/or smoke rated assemblies shall have sleeves installed as required by the manufacturer of the rating seal used.
C. At all other locations either pipe sleeves or core drilled openings are acceptable.

D. Where thermal expansion does not occur, the wall may be sealed tight to the pipe or insulation.

E. Insulation, that requires a vapor barrier (i.e., cold water or refrigerant piping, etc.), must be continuous through the sleeve/cored hole. For other piping, insulation may stop on either side of the sleeve.

F. Sleeves shall be constructed of 24 gauge galvanized sheet steel with lock seam joints or Schedule 40 pipe. Sleeves in floors shall extend 1" above finished floor level.

G. Fasten sleeves securely in floors, walls, so that they will not become displaced when concrete is poured or when other construction is built around them. Take precautions to prevent concrete, plaster or other materials being forced into the space between pipe and sleeve during construction.

H. In all areas where ducts are exposed and ducts pass thru floors, the opening shall be surrounded by a 4 inch high by 3 inch wide concrete curb.

I. Escutcheon plates shall be provided for all pipes and conduit passing thru walls, floors and ceilings. Plates shall be nickel plated, of the split ring type, of size to match the pipe or conduit. Where plates are provided for pipes passing thru sleeves which extend above the floor surface, provide deep recessed plates to conceal the pipe sleeves.

3. CUTTING

A. All rectangular or special shaped openings in plaster, stucco or similar materials, including gypsum board, shall be framed by means of plaster frames, casing beads, wood or metal angle members as required. The intent of this requirement is to provide smooth even termination of wall, floor and ceiling finishes as well as to provide a fastening means for grilles, diffusers, lighting fixtures, etc.

B. Mechanical, plumbing, and fire protection contractors shall coordinate all openings in new and existing masonry walls with the General Contractor; and, unless otherwise indicated on the Architectural drawings, provide lintels for all openings required for the work (Louvers, wall boxes, exhaust fans, etc.). Lintels shall be sized as follows:

1. New Openings under 48" in width: Provide one 3-1/2"x3-1/2"x3/8" steel angle for each 4" of masonry width. Lintel shall have 8" bearing on either side.

2. New Openings 48" to 96" in width: Provide one 3-1/2"x6"x3/8" steel angle for each 4" of masonry width. Lintel shall have 8" bearing on either side.

3. New Openings over 96" in width: Consult the Project Structural Engineer.
C. No cutting is to be done at points or in a manner that will weaken the structure and unnecessary cutting must be avoided. If in doubt, contact the Engineer.

D. Pipe openings in slabs and walls shall be cut with core drill. Hammer devices will not be permitted. Edges of trenches and large openings shall be scribe cut with a masonry saw.

E. Openings in metal building walls shall be made in strict accord with building suppliers recommendations.

4. PATCHING AND REPAIRING

A. Patching and repairing made necessary by work performed under this division shall be included as a part of the work and shall be done by skilled mechanics of the trade or trades for work cut or damaged, in strict accordance with the provisions herein before specified for work of like type to match adjacent surfaces and in a manner acceptable to the Engineer.

B. Where portions of existing lawns, shrubs, paving, etc. are disturbed for installation of work of this Division, such items shall be repaired and/or replaced to the satisfaction of the Engineer.

C. Where the installation of conduit, ducts, piping, etc. requires the penetration of fire or smoke rated walls, ceilings or floors, the space around such conduit, duct, pipe, etc., shall be tightly filled with an approved non-combustible fire insulating material satisfactory to maintain the rating integrity of the wall, floor or ceilings affected.

D. Where ducts penetrate fire rated assemblies, fire dampers shall be provided with an appropriate access door.

E. Piping passing through floors, ceilings and walls in finished areas, unless otherwise specified, shall be fitted with chrome plated brass escutcheons of sufficient outside diameter to amply cover the sleeved openings and an inside diameter to closely fit the pipe around which it is installed.

F. Stainless steel collars shall be provided around all ducts, large pipes, etc., at all wall penetrations; both sides.

G. Where ducts, pipes, and conduits pass through interior or exterior walls, the wall openings shall be sealed air tight. This shall include sealing on both sides of the wall to insure air does not enter or exit the wall cavity. This is especially critical on exterior walls where the wall cavity may be vented to the exterior.

H. When installing conduit, pipe, or any other work in insulated concrete form (ICF) walls, the responsible subcontractor for the work shall provide spray foam insulation to patch the rigid insulation to maintain full integrity of the insulating value of the wall after the mechanical and electrical work is complete. Furthermore all new work shall NOT be installed in concrete center of wall. All mechanical and electrical installations shall be on the interior side of the concrete.
SECTION 15040 - EXCAVATION, TRENCHING, BACKFILLING AND GRADING

1. GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, General Conditions-Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.

B. The Contractor shall include all excavating, filling, grading, and related items required to complete his work as shown on the drawings and specified herein or as required to complete, connect and place all mechanical systems in satisfactory operation.

C. Unless otherwise shown or required, provide separate trenches for sewers, water lines and other underground raceways, with a minimum of 10 feet measured from outside diameter between pipes. In locations, such as close to buildings where separate trenches for sewers and water lines are impractical, lay the water pipe on a solid shelf at least 2'-0" above the top of the sewer and 2-0" to the side. Electric and fuel lines shall always be placed in a separate trench. All exterior lines shall have a minimum earth cover of thirty (30) inches to top of pipe, unless otherwise indicated.

D. Water lines crossing under sewer lines, or crossing less than 2 feet above sewer lines, must be encased for a distance not less than 5 feet on either side of the point of crossover.

2. SUBSURFACE DATA

A. Materials to be excavated shall be unclassified, and shall include earth, rock, or any other material encountered in the excavating to the depth and extent indicated on the drawings and specified herein. No adjustment in the Contract sum will be made on account of the presence or absence of rock, shale, or other materials encountered in the excavating. This paragraph is written to include the removal of all rock with no extras, whether rock is indicated or not.

3. BENCH MARKS AND MONUMENTS

A. Maintain carefully all bench marks, monuments and other reference points. If disturbed or destroyed, replace as directed.

4. EXCAVATION

A. Excavate trenches of sufficient width for proper installation of the work. When the depth of backfill over sewer pipe exceeds 10 feet, keep the trench at the level of the top of the pipe as narrow as practicable. Trench excavation for piping eight inches and smaller shall not exceed thirty inch width for exterior lines and twenty-four inch width for interior lines.

B. Sheet and brace trenches as necessary to protect workmen and adjacent structures. Comply with local regulations or, in the absence thereof, with the "Manual of Accident Prevention in
Construction of the Associated General Contractors of America, Inc., and current OSHA Standards. Do not remove sheeting until trench is backfilled sufficiently to protect pipe and prevent injurious caving. Where removal of sheeting and/or bracing is hazardous, leave in place. Cut off such sheeting not to be removed at least 3 feet below finished grade.

C. Rules and regulations governing the respective utilities shall be observed in executing all work under this heading. Active utilities discovered in the course of excavation shall be protected or relocated in accordance with written instructions from the Engineer. Inactive and abandoned utilities encountered in trenching operations shall be removed and abandoned with ends plugged or capped in accord with current codes and safe practice. If in doubt, contact Engineers. Machine excavation shall not be allowed within ten (10) feet of existing electric lines or lines carrying combustible materials. Use only hand tools.

D. The removal of rock shall be accomplished by use of hand or power tools only. Blasting shall not be permitted unless authorized in writing by the Engineer. Any damage to existing structures, exterior services, or rock intended for bearing, shall be corrected at the Contractor's expense.

E. Perform final grading of trench bottoms by hand tools; carry machine excavation only to such depth that soil bearing for pipes and raceways will not be disturbed. Grade the bottom of trenches evenly to ensure uniform bearing for all piping and raceways. Cut bell holes as necessary for joints and jointmaking. Except as hereinafter specified, bottom of trenches for bell and spigot pipe, flanged pipe, etc. shall be shaped to the lower quadrant of pipe with additional excavation for bell or flange. Piping installed where it rests on bell, or flange and/or is supported with blocks or wedges will not be accepted.

F. Keep trenches free from water while construction therein is in progress. Under no circumstances lay pipe or appurtenances in water. Pump or bail water from bell holes to permit proper jointing of pipe. Any water pumping from this Contractor's trenches which is required during construction, shall be included in this Contract.

G. In no case shall excavation work be accomplished that will damage in any way the new structure, existing structures, equipment, utility lines, large trees to remain, etc. The Contractors shall take the necessary steps to prevent flow of eroded earth by water or landslide onto the property of others, or against the structures. The repair of all such damage or any other damage incurred in the course of excavation shall be borne by the responsible Contractor.

H. Use surveyor's level to establish elevations and grades.

I. The Contractor shall accept the site as he finds it and remove all trash, rubbish and material from the site prior to starting excavation of his work.

J. The Contractor shall provide and maintain barricades and temporary bridges around excavations as required for safety. Temporary bridges shall be provided where excavations cross paved areas and walks. The Contractor shall maintain these bridges in a safe and passable condition for all construction.
traffic until removal. Refer to OSHA Standards for such installations and comply with same in all details.

K. Pay particular attention to existing utilities and lines to avoid damage. The locations of existing lines which are indicated on the plans were taken unconfirmed from drawings prepared for previous construction and locations are approximate only. Also, certain water, gas, electric, storm and sanitary sewer lines and other underground appurtenances, active or abandoned, may not appear on the drawings. It shall be each Mechanical Contractor's responsibility to ascertain the location of all lines and excavate with caution in their area.

5. BACKFILL AND SURFACE REPAIR

A. Backfilling for mechanical work shall include all trenches, manhole pits, storage tank pits, and/or any other earth and/or rock openings which are excavated under this Contract. Backfilling shall be carefully performed and the surface restored to its original level to receive new finish. Wherever trenches and earth openings have not been properly filled and/or settlement occurs, they shall be re-excavated, re-filled and properly compacted, smoothed off and finally made to conform to the level of the original ground surface.

B. Unless otherwise indicated or specified, all piping shall be bedded on four (4) inches minimum of compacted naturally or artificially graded mixture of crushed gravel, crushed stone, or crushed sand with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve on undisturbed soil excavated as described hereinbefore. Install tracer wire above pipe. Cover the pipe with twelve (12) inches of compacted backfill to prevent settlement above and around the new pipe. The backfill shall be naturally or artificially graded mixture of crushed gravel, crushed stone, or crushed sand with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve. Prior to placing this second level of backfill, apply all required coatings and coverings to pipe, apply required tests and check the grading of the pipe to insure that it is correct and that the pipe is free of swags, bows or bends. Also check lines for leaks at this point and repair as required. Once all of the preceding is accomplished, continue backfill with clean, debris and rock free earth tamped at six (6) inch intervals. Finish the backfill as specified following. Note: Water settling of backfill will be permitted only as an aid to mechanical compacting.

(1) When installing any type of pipe below building footing, parallel or perpendicular to the footing, the area underneath the footing and in the zone of influence shall be backfilled with cementitious flowable fill. The zone of influence is the area within a 45 degree angle projecting down from the bottom edge of footers on all sides of the footing. Piping within flowable fill shall be isolated from the fill by a layer of heavy duty felt paper. Piping installed in trenches backfilled with flowable fill shall be anchored to the soil below prior to backfilling.

C. Backfill beneath areas to be seeded or sodded within six (6) inches of finished grade. The remaining six (6) inches shall be backfilled with clean top soil.
D. Backfill beneath paved areas, walks, etc. shall be brought to proper grade to receive the sub-base and paving. No paving shall be placed on uncompacted fill or unstable soil.

E. Backfill for natural gas lines shall be in strict accordance with the utility company or local municipalities requirements. If in doubt, contact the utility company or local municipality and/or the Engineer.

F. Backfill for lines carrying hazardous or combustible materials shall be in accordance with current codes, rules, regulations and safe practices. If in doubt, contact the Engineers.

G. Wherever, in the opinion of the Engineer, the soil at or below the requisite pipe grade is unsuitable for supporting piping, special support shall be provided as directed by the Engineer.

H. Unsuitable material and surplus excavated material not required for backfill shall be removed from the site. The location of dump and length of haul shall be the affected Contractor's responsibility.

I. Provide and place any additional fill material from off the site as may be required for backfill. Fill obtained from off site shall be of kind and quality as specified for backfill and the source approved by the Engineer and shall be brought to the site by the Contractor requiring the fill.

J. In the absence (if not specified or indicated elsewhere in the drawings or specifications to be done by others) of such work by others, the Contractor shall lay new sod over his excavation work. Level, compress and water in accord with sound sodding practice.

K. When running any type of piping below a footer or in the zone of influence the piping shall be backfilled with cementitious flowable fill. The zone of influence is the area under the footer within a 45 degree angle projecting down from the bottom edge of the footer on all sides of the footer. Additionally, grease traps, manholes, vaults, and other underground structures shall be held away from building walls far enough to be outside of the zone of influence.

L. Warning Tape and Tracer Wire

Provide a yellow and black plastic tape in all trenches 6" above the buried utility that identifies the utility about to be encountered. For non-metallic pipe a #12 copper wire shall also be laid in the trench to aid in future location of the piping. A foil faced warning tape may be used in lieu of the plastic tape and wire.

M. All manholes, vaults, and similar underground structures shall have the top elevation set flush with finished grade unless specifically noted otherwise.

6. MINIMUM DEPTHS OF BURY (TO TOP OF PIPE)

In the absence of other indication, the following shall be the minimum depth of bury of exterior utility lines. (Check drawings for variations).
A. Domestic Water Lines ................................................................. 36 inches.

B. Fire Protection Lines ................................................................. 42 inches.

C. Storm Lines ............................................................................. 20 inches.

D. Sanitary Lines (Exterior) .......................................................... 36 inches.

E. Natural Gas Lines ................................................................. 36 inches.

F. Other lines carrying combustible and/or hazardous materials ........... 36 inches.

END OF SECTION 15040
SECTION 15060 - HANGERS, CLAMPS, ATTACHMENTS, ETC.

1. GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, General Provisions - Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.

B. Each Contractor's attention is also directed to Section 15100, Pipe, Pipe Fittings and Pipe Support.

C. This section includes, but is not limited to, furnishing and installing dampers, supports, anchors, and accessories for piping, ductwork, equipment, etc. Furnishing and installing shall be by each trade for the completion of their work.

D. Power driven anchors and expansion anchors shall be permitted only when permission is granted in writing by the Architect and Engineer.

2. MATERIALS AND EQUIPMENT

A. Hangers, Clamps, Attachments, Etc.:

<table>
<thead>
<tr>
<th>SIZE</th>
<th>SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pipe Rings</td>
<td>2&quot; pipe and smaller</td>
</tr>
<tr>
<td></td>
<td>Adjustable swivel split ring or split pipe ring, Grinnell Figures 104 and 108, Elcen, Fee &amp; Mason, or approved equivalent.</td>
</tr>
<tr>
<td>2. Pipe Clevis</td>
<td>2-1/2&quot; pipe and larger</td>
</tr>
<tr>
<td></td>
<td>Adjustable wrought Clevis type, Grinnell Figure 260, Elcen, Fee &amp; Mason, or approved equivalent.</td>
</tr>
<tr>
<td>3. Pipe Clevis</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>Steel Clevis for insulated pipe, Elcen Figure 12A, Grinnell, Fee &amp; Mason or approved equivalent.</td>
</tr>
<tr>
<td>4. Rise Clamps</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>Extension pipe or riser clamp, Grinnell Figure 261, Elcen, Fee &amp; Mason or approved equivalent.</td>
</tr>
<tr>
<td>5. Beam Clamps and Attachments</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>Grinnell Figure numbers listed or, Elcen, Fee &amp; Mason, or approved equivalent. Malleable beam clamp with extension piece figure 229; I-beam clamp figure 131; C-clamp figures 83, 84, 85, 86, 87, and 88.</td>
</tr>
<tr>
<td>6. Brackets</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>Welded steel brackets medium weight,</td>
</tr>
<tr>
<td>7. Concrete Inserts</td>
<td>All</td>
</tr>
<tr>
<td>8. Concrete Fasteners</td>
<td>All</td>
</tr>
<tr>
<td>9. Ceiling</td>
<td>All</td>
</tr>
<tr>
<td>10. Rod Attachments</td>
<td>All</td>
</tr>
<tr>
<td>11. U-Bolts</td>
<td>All</td>
</tr>
<tr>
<td>12. Welded Pipe Saddles</td>
<td>All</td>
</tr>
<tr>
<td>13. Pipe Roll</td>
<td>All</td>
</tr>
<tr>
<td>14. Protection Saddle</td>
<td>All</td>
</tr>
<tr>
<td>16. Miscellaneous Steel</td>
<td>All</td>
</tr>
</tbody>
</table>
17. Concrete Channel Inserts

| All | Continuous slot inserts, Unistrut, or approved equivalent. Heavy duty Series P-3200 or Light Duty Series P-3300 as required. |

18. Adjustable Spot Insert

| All | Adjustable spot insert Unistrut, or approved equivalent, P-3245. Design load 1000 lbs. |

### 3. INSTALLATION

A. Unless otherwise specifically indicated or hereinafter specified in the specifications, all supporting, hanging and anchoring of piping, ductwork, equipment, etc., shall be done by each trade as is necessary for completion of the work and shall be as directed in the following paragraphs:

1. Supporting and hanging shall be done so that excessive load will not be placed on any one hangers so as to allow for proper pitch and expansion of piping. Hangers and supports shall be placed as near as possible to joints, turns and branches.

2. For concrete construction, utilize adjustable concrete inserts for fasteners. Expansion anchors and power driven devices may be used when approved in writing by the Architect/Engineer. Utilize beam clamps for fastening to steel joists and beams and expansion anchors in masonry construction. When piping is run in joists, piping shall be top mounted on trapeze type hangers with each pipe individually clamped to trapeze hanger.

3. Trapeze hangers shall be supported by steel rods of sufficient diameter to support piping from joists or concrete construction. Where desired or required, piping may be double mounted on trapeze hangers. Where conditions permit, trapeze hangers may be surface mounted on exposed joists by means of approved beam clamps, or to concrete construction by means of approved adjustable inserts or expansion anchors.

4. Install all miscellaneous steel other than designed building structural members as required to provide means of securing hangers, supports, etc., where piping does not pass directly below or cross steel joists.

5. Piping shall not be supported by the equipment to which it is connected. Support all piping so as to remove any load or stress from the equipment.

6. Where piping, etc., is run vertically, approved riser clamps, brackets or other means shall be utilized at approximately 10'-0" center to center minimum and an approved adjustable base stand or fitting on concrete support base shall be utilized at the base of the vertical run.
(7) Where piping is run along walls, knee braced angle frames or pipe brackets with saddles, clamps, and rollers (where required) mounted on structural brackets fastened to walls or columns shall be used.

(8) Support all ceiling hung equipment, with approved vibration isolators.

(9) Where copper tubing is specified, hangers shall be of copper clad type when piping is uninsulated.

(10) Uninsulated piping hung from above shall be supported with ring and clevis type pipe hangers. Uninsulated piping mounted on trapeze and wall bracket type support shall be held in place with U-bolts. U-bolts shall allow for axial movement in the piping.

(11) All insulated piping shall be supported with clevis type and/or pipe roll hangers. Hangers shall be sized to allow the pipe insulation to pass through the hangers. Install insulation protection saddles at all hanger locations. Welded pipe saddles shall be installed at all hangers on piping 5" and larger. The pipe saddles shall be sized for the thickness of insulation used. Hangers shall fit snugly around outside of insulation saddles.

(12) Under no conditions will perforated band iron or steel wire driven hangers be permitted.

(13) In general, support piping at the following spacing:

a. Steel and copper piping - 8 foot intervals for piping 3" and smaller; 10 foot intervals for larger piping.

b. Polyethylene piping – 4 foot intervals for piping 2” and smaller.  5 foot intervals for 3” pipe.  6 foot intervals for 4”, 6”, and 8” pipe.  7 foot intervals for 10” and larger pipe.

c. PVC piping – 4 foot intervals for piping 1 1/2” and smaller.  5 foot intervals for 2 and 2 1/2” piping.  6 foot intervals for 3” pipe and larger.

d. Where the manufacturer of the pipe has more strict guidelines, the manufacturer’s recommendations shall be followed.
SECTION 15075 – IDENTIFICATIONS, TAGS, CHARTS, ETC.

1. GENERAL

   A. The Contractor’s attention is directed to the General and Special Conditions, General Conditions-Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other Contract Documents which affect the work of this section and which are hereby made a part of the work specified herein.

2. VALVE TAGS AND CHARTS

   A. Provide and install on each valve in the Mechanical Systems a 1-1/2” diameter circular brass tag fitted to each valve so that it cannot be removed. Each tag shall be embossed consecutively with letter and number identifiers as to system and purpose respectively. Letter identifiers shall be as follows:

      H    Heating
      DCW  Domestic Cold Water
      DHW  Domestic Hot Water
      RHW  Recirculating Hot Water
      FP   Fire Protection
      NG   Natural Gas

   Number identifiers shall be determined by the Contractor sequentially. For example, valve No. HC-1 may be maintenance stops for fan coil units. HC-2 maintenance stops for air heaters, etc.

   B. Provide three (3) copies of typewritten valve charts indicating each valve identifier, the valves purpose and its location. For example: “HC-1 Fan Coil Maintenance Stop—one valve at supply and return of each fan coil unit.” One (1) copy of this chart shall be mounted in suitable wood frame(s) with clear plastic or glass covers in a conspicuous location in the Mechanical Room. Two other copies shall be turned over to the Engineers.

   C. Where more than one major Mechanical room is indicated for the project, install mounted valve schedule in each major Mechanical Room, and repeat only main valves which are to be operated in conjunction with operations of more than single Mechanical Room.

3. PIPING IDENTIFICATION

   A. GENERAL

      (1) Provide stenciled markers and arrows indicating direction of flow on all piping installed under this Contract. Markers and arrows shall be painted on the piping using machine cut stencils. All letters shall be sprayed using fast drying lacquer paint. All markers and arrows shall be properly oriented so that descriptive name may be easily read from the floor. At the Contractor’s option, Setmark or equivalent manufactured marking system may be substituted for field marking. The following table describes the size of the color field and size of the identification letter which shall be used for pipes of different outside pipe diameters.
(2) “Concealed”, where used herein, shall mean hidden from sight as in trenches, chases, furred spaces, pipe shafts, or above hung finished ceilings. “Exposed” shall mean that piping or equipment is not “concealed” as defined above. Piping and equipment in service tunnels, mechanical equipment rooms, storage areas, or unfinished rooms is to be considered as “exposed”.

(3) All piping shall be marked not less than every 15 linear feet above a ceiling system, every 10 feet in a mechanical room, and at all points where lines pass through walls or floors.

(4) Provide pipe marker colors as indicated in the following table where manufactured marking systems are used:

<table>
<thead>
<tr>
<th>PIPE+</th>
<th>MARKER COLOR+</th>
<th>ABBREVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Water Supply</td>
<td>Yellow with Black Letters</td>
<td>H.W.S.</td>
</tr>
<tr>
<td>Hot Water Return</td>
<td>Yellow with Black Letters</td>
<td>H.W.R.</td>
</tr>
<tr>
<td>Domestic Cold Water</td>
<td>Green with Black Letters</td>
<td>D.C.W.</td>
</tr>
<tr>
<td>Domestic Hot Water</td>
<td>Yellow with Black Letters</td>
<td>D.H.W.</td>
</tr>
<tr>
<td>Recirculated Hot Water</td>
<td>Green with Black Letters</td>
<td>R.H.W.</td>
</tr>
<tr>
<td>Compressed Air</td>
<td>Blue with White Letters</td>
<td>C.A.</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Yellow with Black Letters</td>
<td>NAT. GAS</td>
</tr>
<tr>
<td>Sanitary Sewer Piping</td>
<td>Green with Black Letters</td>
<td>SAN.</td>
</tr>
<tr>
<td>Sanitary Vent Piping</td>
<td>Green with Black Letters</td>
<td>VENT</td>
</tr>
<tr>
<td>Storm Sewer Piping</td>
<td>Green with Black Letters</td>
<td>STORM</td>
</tr>
<tr>
<td>Fire Protection Water</td>
<td>Red with White Letters</td>
<td>F.P.</td>
</tr>
</tbody>
</table>

A. Piping, whether exposed or concealed, shall be marked not less than every 15 linear feet and at the points where the piping passes through wall or floors.

4. PIPE PAINTING (REFER ALSO TO ARCHITECTURAL SECTION ON PAINTING)

A. GENERAL

(1) All exposed piping installed shall be painted according to the color coding chart hereinafter specified.

(2) “Concealed”, where used herein, shall mean hidden from sight as in trenches, chases, furred spaces, pipe shafts, or above hung finished ceilings. “Exposed” shall mean that piping or equipment is not “concealed” as defined above. Piping and equipment in service tunnels, mechanical equipment rooms, storage areas, or unfinished rooms is to be considered as “exposed”.
(3) Paint all equipment and metal surfaces which are not factory finished (and all damaged or rusted surfaces) in high grade rust proofing machinery enamel. Pay particular attention to flanges, valves, unions, etc., where condensation may collect.

(4) Paint exposed pipe (whether insulated or bare) and exposed surfaces (tanks, etc.).

(5) All piping shall be painted in accordance with the following color coding chart.

<table>
<thead>
<tr>
<th>PIPE+</th>
<th>PIPE COLOR CODE+</th>
<th>ABBREVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Water Supply*</td>
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</tr>
<tr>
<td>Fire Protection Water</td>
<td>Red with White Letters</td>
<td>F.P.</td>
</tr>
</tbody>
</table>

* Includes pumps, air separator, valves, compression tanks, etc.

+ Where a pipe is not specifically identified in this table, painting and marking shall be in accordance with the most recent ANSI Standards.

B. Water heaters, storage tanks, heat exchangers, etc., shall be painted light gray.

C. All piping shall be marked. Piping shall be marked not less than every 15 linear feet above a ceiling system, every 10 feet in a mechanical room, and at all points where the piping passes through wall or floors.

5. EQUIPMENT IDENTIFICATION

A. All equipment, except in finished rooms, shall be identified by stenciling the title of the equipment as taken from the plans in a position that is clearly visible from the floor. The letters shall be made with black paint and shall be not less than two inches high. The titles shall be short and concise and abbreviations may be used as long as the meaning is clear. Lamacoid plates are also acceptable. In finished rooms or outdoors, equipment shall be identified by engraved nameplates.
6. DUCTWORK IDENTIFICATION

   A. All ductwork shall be identified as to the service of the duct and direction of flow. The letters shall be at least two inches high and the flow arrow shall be at least six inches long. The letters and flow arrow shall be made by precut stencils and black oil base paint with aerosol can. Concealed ducts need not be identified.

7. ACCESS THROUGH LAY-IN CEILINGS

   A. Mark the ceiling T-bar nearest the ceiling panel access to equipment, valves, damper, filter, duct heaters, etc., with a small red lamacoid plate with name of item above ceiling.

END OF SECTION 15075
SECTION 15080 - INSULATION - MECHANICAL

1. GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, General Conditions-Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified herein.

B. Work under this section shall include all labor, equipment, accessories, materials and services required to furnish and install all insulation, fittings and finishes for all mechanical systems specified herein and/or as indicated.

C. Application of insulation materials shall be done in accordance with manufacturer's written recommendations. Where thickness of insulation is not specified, use applicable thickness recommended by manufacturer for specific use. Insulation shall be applied by a company regularly engaged in the application of insulation and any work deemed unacceptable by the Engineers shall be removed and properly installed at the expense of the Contractor.

2. MANUFACTURERS

A. Insulation shall be as manufactured by Manville, Knauf, CertainTeed, Owens-Corning, Armacell or other approved equivalent. Insulation sundries, adhesives, and jackets/covers shall be as made by Benjamin Foster, Zeston, Speedline, Proto, Childers, Vimasco or approved equivalent.

3. FIRE RATINGS AND STANDARDS

A. Insulations, jackets and facings shall have composite fire and smoke hazard ratings as tested by ASTM E-84, NFPA 255 and UL 723 procedures not exceeding Flame Spread 25, Smoke Developed 50.

B. Adhesives, mastics, tapes and fitting materials shall have component ratings as listed above.

C. All products and their packaging shall bear a label indicating above requirements are not exceeded.

D. Duct linings shall meet the Erosion Test Method in compliance with UL Publication No. 181.

4. GENERAL APPLICATION REQUIREMENTS

A. Insulation shall be applied on clean, dry surfaces in a neat and workmanlike manner reflecting the best current practices in the trade. Insulation shall not be applied to piping, ductwork or equipment until tested, inspected and released for insulation.

B. All insulation shall be continuous through walls, ceiling openings and sleeves. However, insulation shall be broken through fire walls. All covered pipe and ductwork is to be located a sufficient distance from walls, other pipe, ductwork and other obstacles to permit the application of the full thickness of insulation specified. If necessary, extra fittings and pipe are to be used. No noticeable deformation of insulation or discontinuity of vapor seal, where required, will be accepted.
C. "Concealed", where used herein, shall mean hidden from sight as in trenches, chases, furred spaces, pipe shafts, or above hung finished ceilings. "Exposed" shall mean that piping or equipment is not "concealed" as defined above. Piping and equipment in service tunnels, mechanical equipment rooms, storage areas, or unfinished rooms is to be considered as "exposed".

D. Existing and/or new insulation removed and/or damaged during course of construction shall be repaired or replaced as directed by the Engineer.

E. Vapor barrier jackets shall be applied with a continuous unbroken vapor seal. Do not use staples thru the jacket. NO EXCEPTIONS!

F. All insulation shall be installed with joints butted firmly together.

G. The Contractor shall ensure that all insulation (piping, ductwork, equipment, etc.) is completely continuous along all conduits, equipment, connection routes, etc. carrying cold fluids (air, water, other) and that condensation can, in no way, collect in or on the insulation, equipment, conduits, etc. Any such occurrence of condensation collection and/or damage therefrom shall be repaired solely at the expense of the Contractor.

5. PIPING SYSTEMS

A. GENERAL

(1) Bevel insulation and jacket at all points where insulation terminates at unions, flanges, valves and equipment. Note: Applies to hot water lines only; cold water lines require continuous insulation.

(2) Pipe insulation shall extend around valve bodies to above drain pans in hydronic equipment over pumps, etc. to ensure no condensation drip or collection.

(3) Factory molded fittings may be installed in lieu of built-up fittings. Jackets to be the same as adjoining insulation. Insulated fittings must have same or better K factors than adjoining straight run insulation.

(4) Valves, flanges and unions shall only be insulated when installed on piping whose surface temperature will be at or below the dew point temperature of the ambient air.

(5) Insulation shall not extend through fire and smoke walls. A UL-listed penetration system shall be used for each fire or smoke wall penetration in accordance with KBC. Materials used such as caulk, sleeves, etc. shall be manufactured by 3M, Hilti, or equal.

B. INSULATION SHIELDS

(1) Metal insulation shields are required at all pipe hangers where the piping is insulated. Metal shields shall be constructed of galvanized steel, formed to a 180 degree arc. Insulation shields shall be the following size:
<table>
<thead>
<tr>
<th>PIPE SIZE</th>
<th>SHIELD GAUGE</th>
<th>SHIELD LENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot; AND LESS</td>
<td>20</td>
<td>12&quot;</td>
</tr>
<tr>
<td>2 1/2&quot; TO 4&quot;</td>
<td>18</td>
<td>12&quot;</td>
</tr>
<tr>
<td>5&quot; TO 10&quot;</td>
<td>16</td>
<td>18&quot;</td>
</tr>
<tr>
<td>12&quot; AND GREATER</td>
<td>14</td>
<td>24&quot;</td>
</tr>
</tbody>
</table>

C. INSULATION MATERIAL (FOR THE FOLLOWING SYSTEMS)

Insulation shall be Owens-Corning Model 25ASJ/SSL, or approved equivalent fiberglass pipe insulation with an all service jacket. The insulation shall be a heavy density, pipe insulation with a K factor .23 at 75°F mean temperature. The insulation shall be wrapped with a vapor barrier jacket approved manufacturers are listed in section 2. Manufacturers. The jacket shall have an inside foil surface with self sealing lap and a water vapor permeability of .02 perm/inch. All circumferential joints shall be vapor sealed with butt strips. All insulation shall be installed in strict accordance with the manufacturers’ recommendations. The following pipes shall be insulated with the thickness of insulation as noted.

(1) Domestic Cold Water
   a. Piping 3’’ or less – use 1/2” thick insulation. Provide an additional ½” layer of insulation 3” above and 3” below vertical pipe supports.
   b. Piping 4’’ or greater – use 1” thick insulation.

(2) Hydronic System Fill Lines from Domestic Cold Water - 1/2” thick.

(3) Domestic 110°F Hot Water and 110°F Recirculating Hot Water. (If heat traced, see below)
   a. Piping 1 ½’’ or less – use 1 ½’’ thick insulation.
   b. Piping 2’’ or greater – use 2’’ thick insulation.

(4) Domestic 140°F Hot Water and 140°F Recirculating Hot Water. (If heat traced, see below)
   a. Piping 1 ½’’ or less – use 1 ½’’ thick insulation.
   b. Piping 2’’ or greater – use 2’’ thick insulation.

(5) Domestic Hot Water with Heat Tape for Heat Maintenance - Insulation thicknesses as required by the manufacturer to maintain water temperature.

(6) Hydronic Hot Water.
a. Piping 1 ½'' or less – use 1 ½'' thick insulation  
b. Piping 2'' or greater – use 2'' thick insulation  

(7) Horizontal Roof Leaders.  
a. Piping 3'' or less – use 1/2'' thick insulation  
b. Piping 4'' or greater – use 1'' thick insulation  

(8) Sanitary Sewer and plumbing fixture P-traps to waste stack – see schedule below. Insulate horizontal runs which receive air conditioning condensate and which are not located below slab or grade.  
a. Piping 3'' or less – use 1/2'' thick insulation  
b. Piping 4'' or greater – use 1'' thick insulation  

(9) Condensate Drain Lines.  
a. Piping 1 ½'' or less – use 1/2'' thick insulation  
b. Piping 2'' or greater – use 1'' thick insulation  

(10) Refrigerant Liquid and Suction Lines - Interior & Exterior  

IMCOA, Nomaco, or Armacell closed cell polyethylene, 1.5 Lbs/Ft³ density, 0.24 BTU-Hr.-Ft³-°F/in at 75°F thermal conductivity, zero vapor permeance, 25/50 flame and smoke spread per NFPA 90 requirements. Elastomeric closed cell insulations that meet the above requirements are also allowed. Install insulation per the manufacturer’s requirements.  
a. All pipe sizes: 1 ½'' thick  

D. JACKETS  

(1) Exposed (Mechanical Rooms, Interior Finished Rooms and Storage Rooms)  

All insulated piping installed in the above areas shall have a canvas or PVC jacket:  
a. 6 oz. canvas jacket with fire retardant lagging. Apply to the insulation specified for the piping.  
b. For all systems except steam, plenum rated PVC jacket equal to LoSmoke PVC jacket with flame/smoke rating of 25/50, ASTM-E84 test method. Minimum thickness 0.04 inches. Steam systems shall utilize plenum rated CPVC jacket with minimum thickness of 0.04 inches. Jackets shall be applied over top of specified pipe insulation. Approved equal manufacturers are Zeston and Speedline. Approved equal manufacturers are Zeston and Speedline.
(2) Exposed (Exterior)

In addition to the insulation specified for the exterior pipe, provide .016" aluminum jacket or PVC jacket 0.05" thick. The jackets shall be installed as recommended by the manufacturer to maintain water tight seal. All longitudinal and transverse seams to be sealed water tight. PVC jacket shall be Ceel-Co, Proto, or Zeston.

6. DUCTWORK SYSTEMS

A. GENERAL

(1) Duct sizes indicated are the net free area inside clear dimensions; where ducts are internally lined, overall dimensions shall be increased accordingly.

(2) Duct insulation shall extend completely to all registers, grilles, diffusers, and louver outlets, etc., to insure no condensation drip or collection. The backs of all supply diffusers, plenums, grilles, etc. shall be insulated only if indicated by details on the drawings.

(3) All flexible duct connections on insulated ductwork shall be externally insulated.

(4) All duct outside of building envelope, including rooftop duct, duct in unconditioned attic spaces above the insulation, etc. shall have two layers of specified insulation. This shall apply to supply air, exhaust air where air is run through energy recovery unit, outside air, return air, and combustion air intake ducts.

B. EXTERNAL INSULATION

(1) Supply Air (SA)
(2) Return Air (RA)
(3) Outside Air (OA)
(4) Exhaust Air (EA)
(5) Boiler Combustion Air (CAI)
(6) Flexible Duct Connections on Internally Lined Ducts

Owens/Corning “Faced Duct Wrap - Type 100”, or approved equal, 2" thick fiberglass duct wrap, 1.0 pcf density factory laminated to a reinforced foil kraft vapor barrier facing (FRK) with a 2” stapling flange at one edge. Flame spread 24, smoke developed 50, vapor barrier performance 0.02 perms per inch. K factor shall not exceed .26 at 75°F. mean temperature. Minimum R-value of the 2” thick insulation shall be 7.4 out of package and 6.0 installed.

Special Notes:

a. Do not provide externally insulated duct per the above specification for any duct that is to be painted. Insulated duct that is to be painted shall be dual wall ductwork per specification Section 231200, Sheet Metal and Flexible Duct.

b. Where supply, return, and outside air ductwork is routed through an unconditioned attic or any other space outside of the building thermal envelope, the ductwork shall be provided with a minimum of 2 layers of duct wrap for a minimum R value of 11.0. Additionally,
this shall apply to exhaust ductwork on entering side of energy recovery type air handling units.

C. EXPOSED EXTERNALLY INSULATED DUCT

(1) Round. 1 ½” semi-rigid fiberglass tank and pipe wrap with kraft aluminum foil all service jacket vapor barrier or PSK facing. K=.27 @ 75°F. Minimum R-value shall be OK. Provide 6 oz. canvas jacket with fire retardant lagging.

(2) Rectangular. 1” rigid fiberglass industrial board with foil scrim kraft vapor barrier facing or PSK facing, 6.0 PCF density, K=.22 @ 75°F. Minimum R-value shall be 5.5. Owens/Corning type 705. Provide 6 oz. canvas jacket with fire retardant lagging.

7. MECHANICAL EQUIPMENT

A. EXPANSION TANK, COMPRESSION TANK, AIR SEPARATOR, HEAT EXCHANGER, SIDESTREAM/LOOP FILTERS, AND HOT WATER STORAGE TANKS

(1) Owens-Corning “Tank Wrap I” or approved equivalent. Insulation shall be constructed of non-combustible, flexible wool. Insulation shall be 2” thick. K factor shall be .29 at 100°F. mean temperature. Insulation shall be attached in strict accordance with the manufacturer’s recommendations. All insulation shall be jacketed with 6 oz. canvas with fire retardant lagging. Coordinate with mechanical contractor to extend all piping connections, blowdown ports, etc. outside of the insulation. Additionally for loop filters and other equipment requiring periodic service, provide removable insulated covers.

END OF SECTION 15080
SECTION 15095 - COORDINATION AMONG TRADES, SYSTEMS INTERFACING AND CONNECTION OF EQUIPMENT FURNISHED BY OTHERS

1. COORDINATION

A. The Contractor is expressly directed to read the General Conditions and all detailed sections of these specifications for all other trades and to study all drawings applicable to his work, including Architectural and Structural drawings, to the end that complete coordination between trades will be affected. Special attention shall be given to the points where ducts or piping must cross other ducts or piping, where lighting fixtures must be recessed in ceilings, and where ducts, piping and conduit must fur into walls, soffits, columns, etc. It shall be the responsibility of the Contractor to leave the necessary room for other trades. No extra compensation will be allowed to cover the cost of removing piping, conduit, ducts, etc., or equipment found encroaching on space required by others.

B. The Contractor shall be responsible for coordination with the Electrical trade to insure that he has made provision for connections, operational switches, disconnect switches, fused disconnects, etc. for electrically operated equipment provided under this division of the specifications, or called for on the plans.

C. If any discrepancies occur between accompanying drawings and these specifications and drawings and specifications covering other Contracts, each trade shall report such discrepancies to the Architect far enough in advance so that a workable solution can be presented. No extra payment will be allowed for relocation of piping, ductwork, conduit, and equipment not installed in accordance with the above instructions, and which interfered with work and equipment of other trades.

D. In all areas where air diffusers and lighting fixtures are to be installed, the Contractor shall coordinate their respective construction and installations so as to provide a combined symmetrical arrangements.

2. INTERFACING

The Contractor shall insure that coordination is affected relative to interfacing of systems. Some interface points are (but not necessarily all):

A. Connection of Domestic Water System to water service mains.

B. Connection of Natural Gas System to natural gas service.

C. Connection of Fire Protection System to domestic water service.

D. Connection of Sanitary sewer house line to municipal service.

E. Connection of Storm Drainage System to municipal system.
F. Connection of Domestic Water System to Hydronic System.

G. Connection of all controls to equipment.

H. Electrical power connections to electrically operated (or controlled) equipment.

3. CONNECTION OF EQUIPMENT FURNISHED BY OTHERS

A. The Contractor shall make all connections to equipment furnished by others, or relocated from the existing structure, whenever such equipment is shown on any part of the drawings or mentioned in any part of the Specifications, unless otherwise specifically specified hereinafter.

B. Supervision to assure proper functioning and operation shall be provided by the Contractor.

C. Items indicated on the drawings as rough-in only (RIO) will be connected by others. The Contractor shall be responsible for rough-in provisions only.

D. For items furnished by others, relocated, or RIO, the Contractor shall obtain from the supplier or shall field determine as appropriate, the exact rough-in locations and connection sizes for the referenced equipment.

E. The Contractor shall be responsible for coordinating to determine any and all final connections that he is to make to equipment furnished by others.

4. RECORD DRAWINGS

(1) RECORD DRAWINGS - Each Contractor shall insure that any deviations from the Coordination Drawings are recorded as they occur, in red erasable pencil on Coordination Drawings kept at the jobsite. Upon completion of a particular phase, the Mechanical Contractor shall incorporate all field deviations into the Coordination Drawings to be utilized as Record Drawings. The Engineer shall review the Record Documents from time to time to insure compliance with this specification. Compliance shall be a contingency of final payment. Pay particular attention to the location of under floor sanitary and water lines, shut-off valves, cleanouts and other appurtenances important to the maintenance and operation of Mechanical Systems. Also, pay particular attention to Deviations in the Control Systems and all exterior utilities. Keep information in a set of drawings set aside at the job site especially for this purpose. The Record Drawings shall be distributed electronically (on CD) to the Construction Manager, Owner, Architect and Engineer for their Records.

END OF SECTION 15095
SECTION 15100 - PIPE, PIPE FITTINGS AND PIPE SUPPORT

1. GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, General Conditions-Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.

B. When a pipe size is not indicated, the Contractor shall request the pipe size from the Engineers. All piping shall be installed straight and true, parallel or perpendicular to the building construction. Piping shall be installed so as to allow for expansion without damage to the building finishes, structure, pipe, equipment, etc., use offsets, U-bends or expansion joints as required. Where a section of piping is not indicated but is obviously required for completion of the system, the Contractor shall provide same at no additional cost to the project. No mitered joints or field fabricated pipe bends shall be accepted. Pipe shall clear all windows, doors, louvers and other building openings.

C. All pipe shall be supported in a neat and workmanlike manner and wherever possible, parallel runs of horizontal piping shall be grouped together on trapeze type hangers. Vertical risers shall be supported at each floor line with approved steel pipe riser clamps. The use of wire or perforated metal to support pipes will not be permitted. Hanging pipes from other pipes shall not be permitted. Spacing of pipe supports shall not exceed eight feet for pipes up to 1-1/4 inches and ten feet on all other piping. Small vertical pipes (1 inch and less) shall be bracketed to walls, structural members, etc. at four (4) foot intervals so as to prevent vibration or damage by occupants. Insulated piping shall be supported on a rigid insulation block at each hanger so as to prevent crushing of insulation by hangers. Hangers shall pass completely around the insulation jacket and a steel protective saddle shall be applied to prevent compression of the insulation. (Refer to Specifications Section entitled INSULATION-MECHANICAL).

D. Where piping rests directly on a hanger, clip, bracket or other means of support, the support element shall be of the same material as the pipe, (e.g., copper to copper, ferrous to ferrous, etc.) or shall be electrically isolated one from the other so as to prevent pipe damage by electrolysis. Pay particular attention and do not allow copper pipe to rest on ferrous structural members, equipment, etc. without electrolytic isolation.

E. In general, piping shall be installed concealed except in Mechanical, Janitor Rooms, etc. unless otherwise indicated, and shall be installed underground or beneath concrete slabs only where indicated. All lines at ceilings shall be held as high as possible and shall run so as to avoid conflicts with other trades, and to facilitate the Owner's use and maintenance. Location of pipe in interior partitions shall be carefully coordinated with whoever will construct the partitions after the piping is in place. Where exposed risers occur they shall be kept as close to walls as possible.

F. Installation of pipe shall be in such a manner as to provide complete drainage of the system toward the source. Drain valves shall be provided at all drainage points on pipes. Drain valves
shall be 1/2" size gate type with 3/4" hose thread end and vacuum breaker. Label each drain valve.

G. All hot and cold water piping shall be kept a sufficient distance apart so as to prevent heat transfer between them. Cold water piping shall also be kept apart from refrigerant hot gas lines.

H. Piping carrying water or other fluids subject to freezing shall not be installed in locations subject to freezing; if in doubt, consult Engineer.

I. Piping for all drainage systems shall be installed to permit flow, trapping, and venting in accord with current codes and sound practice.

J. All cast iron soil pipe and fittings shall be coated inside and out with coal tar varnish.

K. Non-metallic piping shall be installed in strict accordance with the manufacturer's instructions. If no such instructions are available, consult Engineers.

L. Nipples shall be of the same material, composition and weight classification as pipe with which installed.

M. Where piping is not indicated on the plans, but is obviously or apparently required, contact the Engineers prior to submission of a bid proposal.

N. Pay particular attention to conflict of piping with other work. Do not install until conflict is resolved. If necessary, contact Engineers.

O. Piping materials in each system shall, to the extent practicable, be of the same material. Frequent changes of material (for example, from copper to steel) shall be avoided and in no case shall be accomplished without use of insulating unions and permission of the Engineers.

P. Apply approved pipe dope (for service intended) to all male threaded joints. Pay particular attention to dope for fuel gas lines. The dope shall be listed for such use.

Q. High points of closed loop hot water heating systems shall have manual or automatic air vents as indicated or required unless automatic air vents are specifically indicated. Pipe to suitable drainage point.

R. All piping shall be capped or plugged during erection as required to keep clean and debris and moisture free.

S. The entire domestic hot, cold and recirculating hot water piping system shall be sterilized in strict accord with requirements of the Department of Health Codes, Rules and Regulations for the State which the work is being accomplished in.
T. Provide expansion joints where shown on the plans and where required by good practice. Expansion joints shall be guided and anchored in accordance with the recommendations of the Expansion Joint Manufacturer's Association.

U. Where plastic pipe penetrates a fire rated assembly, it shall be replaced with a metal threaded adapter and a metal pipe per code.

V. Where piping penetrates interior or exterior walls, the wall shall be sealed air tight. Refer to the sleeving, cutting, patching and repairing section of the specifications for additional requirements.

W. Provide thrust blocks on all storm, sanitary, water, steam, hot, chilled, condenser, etc., and any other piping subject to hammering. Thrust blocks shall be provided at all turns.

X. All piping to hydronic coils shall be full size all the way to the coil connection on the unit. If control valve is smaller than pipe size indicated, transition immediately before and after control valve. Also, if coil connection at unit is a different size than the branch pipe size indicated, provide transition at coil connection to unit. **On 3-way valve applications, the coil bypass pipe shall be full size.**

Y. Provide check valves on individual hot and cold water supplies to each mixing valve (including each sensor style faucet, safety shower, mop sink, etc.) and each showerhead with a diverter valve (including all ADA showers). This requirement shall not be satisfied by mixing valves or fixtures with internal check valves. Independent external check valves are required.

2. UNIONS AND FLANGES AND WELDED TEES

A. Screwed unions, soldered unions or bolted flanges shall be provided as required to permit removal of equipment, valves and piping accessories from the piping system. Keep adequate clearances for coil removal, rodding, tube replacement, motor lubrication, filter replacement, etc. Flanged joints shall be assembled with appropriate flanges, gaskets and bolting. Gaskets for steam piping systems shall be flexitalic spiral wound type. The clearance between flange faces shall be such that the connections can be gasketed and bolted tight without imposing undue strain on the piping system.

B. Dielectric insulating unions or couplings shall be used wherever the adjoining materials being connected are of dissimilar metals such as connections between copper and steel pipe.

C. Tee connections for welded pipe shall be made up with welding fittings. Where the size of the side outlet is such that a different connection technique than on the run is required, a weldolet, sockolet, or threadolet type fitting may be used for the branch in place of reducing tees only where the branch is 2/3 the run size or smaller.

3. SPECIFICATIONS STANDARDS

All piping and material shall be new, made in the United States and shall conform to the following minimum applicable standards:
A. Steel pipe; ASTM A-120, A-53 Grade A, A-53 Grade B.

B. Copper tube; Type K, L, M; ASTM B88-62; Type DWV ASTM B306-62.

C. Cast iron soil pipe; ASA A-40.1 and CS 188-59.

D. Cast iron drainage fittings; ASA B16.12.

E. Cast iron screwed fittings; ASA B16.4.

F. Welding fittings; ASA B16.9.

G. Cast brass and wrought copper fittings; ASA B16.18.

H. Cast brass drainage fittings; ASA B16.23.

I. Reinforced concrete pipe; ASTM-C-76-64T.

J. Solder; Handy and Harmon, United Wire and Supply; Air Reduction Co. or equivalent.

K. CPVC Plastic pipe; ASTM D2846.

L. PVC plastic pipe; ASTM D1785.

M. ABS plastic pipe; ASTM D1788-73.

N. Cross-linked polyethylene (PEX) pipe; ASTM F876 and ASTM F877.

O. Cross-linked polyethylene (PEX) fittings; ASTM F1960

4. PITCH OF PIPING

All piping systems shall be installed so as to drain to a low point. Certain minimum pitches shall be required for this drainage. For proper flow and/or for proper operation, the following pitches shall be required:

A. Interior Soil, Waste and Vent Piping:

   1/4 inch per foot in direction of flow where possible but in no case less than 1/8" per foot.

B. Exterior Sanitary Lines:

   Not less than one (1) percent fall in direction of flow and no greater than indicated.

C. Roof Leaders:
1/8 inch per foot where possible.

D. Condensate Drain Lines From Cooling Equipment:

Not less than 1/4 inch per foot in direction of flow.

E. Exterior Storm Lines:

Not less than 1 percent grade in direction of flow.

F. All Other Lines:

Provide ample pitch to a low point to allow 100 percent drainage of the system.

5. APPLICATIONS

A. General Notes

(1) Where plastic piping penetrates a fire rated assembly, it shall be replaced with a threaded metal adapter and metal pipe or whatever means necessary to maintain the separation rating in accordance with local plumbing and fire codes.

(2) Plastic piping or any materials with a flame and smoke spread rating not approved for plenum use shall not be permitted in supply, return, relief or exhaust plenums.

(3) PVC, CPVC, or plastic piping shall not be used under paving, roads or areas where vehicular traffic is expected.

(4) PVC or plastic piping whether specifically listed or not may not be used in high rise buildings or anywhere else prohibited by code.

B. Sanitary Sewer – Exterior

(1) Service weight cast iron piping with bell and spigot fittings complying with ASTM A 74. All joints shall be compression gasket type.

(2) SDR 35 PVC pipe extruded from Type 1, Grade 1 polyvinyl chloride material. PVC pipe shall have a bell type fitting on one end. All joints shall be solvent cement type, made in accordance with the Kentucky Plumbing Code.

(3) Service weight hubless cast iron with manufacturer’s approved bands.

C. Storm Sewer – Exterior
(1) Class II reinforced concrete pipe (RCP) with tongue and groove gasketed joints conforming to ASTM C-443.

(2) Service weight cast iron piping with bell and spigot fittings complying with ASTM A 74. All joints shall be lead and oakum caulked type or compression gasket type.

(3) SDR 35 PVC pipe extruded from Type 1, Grade 1 polyvinyl chloride material. PVC pipe shall have a bell type fitting on one end. All joints shall be solvent cement type.

D. Natural Gas Piping - Exterior

Exterior natural gas piping shall be thermoplastic gas pressure pipe with fittings complying with ASTM D 2513. All gas piping shall be installed per NFPA 54. Refer to Civil drawings, specifications, and Elizabethtown’s natural gas departments Natural Gas Code Book and Natural Gas Ordinance documents.

E. Domestic Water Piping - Exterior

(1) Type "K" hard copper with wrought copper fittings and brazed joints.

(2) Schedule 150 ductile iron piping with cement mortar lining and rubber gasketed joints.

(3) Schedule 40 PVC pipe, NSF approved for underground domestic cold water pipe, with solvent weld joints. All piping and joints shall meet the Kentucky Plumbing Code.

(4) Class 200 PVC. Piping shall meet AWWA C900 requirements, be UL listed, Factory Mutual approved and NSF approved. Joints shall have spigot pipe ends with a flexible elastomeric ring seated in a groove to provide water tight seal. Minimum burst pressure to be 900 psi when tested in accordance with ASTM D1599.

F. Fire Protection - Exterior and Interior

Refer to the Fire Protection System section of these specifications.

G. Soil Waste and Vent Piping - General Requirements

(1) Water closet floor flanges and ells shall be cast iron regardless whether PVC piping is allowed or not.

(2) Soil and waste piping serving mechanical rooms, laundries and kitchens shall be cast iron regardless whether PVC piping is allowed or not. Cast iron will also be required at any other location where waste water temperature can exceed 120°F. Cast iron shall extend a minimum of 35' past last waste inlet.

H. Soil, Waste and Vent Piping (Below Slab)
(1) Schedule 40 PVC pipe with drainage pattern fittings and solvent cement joints made in accordance with the Kentucky Plumbing Code.

(2) Service weight hubless cast iron with manufacturer's approved bands.

I. Soil, Waste and Vent Piping (Above Slab)

(1) Service weight hubless cast iron pipe with manufacturer's approved bands.

(2) Service weight cast iron hub and spigot piping with lead and oakum joints or compression gasket joints.

(3) Schedule 40 galvanized steel piping with screwed ends and cast iron drainage pattern fittings for piping 2" and less in size. Provide pipe adapters for connector of cast iron pipe at slab.

(4) Type DWV copper drainage piping with cast bronze drainage pattern fittings with solder joints.

(5) Schedule 40 PVC pipe with drainage pattern fittings and solvent cement joints made in accordance with the Kentucky Plumbing code.

B. Roof Leaders/Interior Storm Sewer Piping

(1) Service weight hubless cast iron pipe with manufacturers approved bands. Horizontal pipe and fittings 6” and larger, shall be suitably braced to prevent horizontal movement. Provide bracing in accordance to CIPI 301-00. Provide “Holdrite” bracing system or approved equal.

(1) Schedule 40 PVC pipe with drainage pattern fittings and solvent cement joints.

C. Sump Pump Discharge

(1) Type “M” copper with solder joints.

(2) Schedule 40 PVC where piping is not installed in a plenum. All piping exposed on the exterior must be copper.

D. Natural Gas Piping – Interior

(1) Schedule 40 black steel pipe with malleable iron threaded fittings for pipe sizes 2" and smaller.

(2) Schedule 40 black steel pipe with wrought steel buttwelded fittings for pipe sizes 2-1/2" and larger.

(3) Where gas pressure is 5 psi or greater, piping shall be schedule 40 black steel pipe with wrought steel buttwelded fittings.
(4) Gas piping on the roof shall have expansion loops on all piping runs 75 feet or greater.

NOTES:

(1) All gas piping shall be installed per NFPA 54.

(2) Unions or valves shall not be installed in an air plenum.

(3) Piping below slab must be sleeved and vented.

(4) Piping installed in concealed locations shall not have mechanical joints.

E. Domestic Cold, Hot and Recirculating Hot Water Piping (Above Slab)

(1) Type "L" hard copper tubing with wrought copper fittings with lead free solder equivalent in performance to 95/5. (Maximum lead content of solder and flux is 2%).

F. Domestic Cold, Hot and Recirculating Hot Water Piping (Below Slab)

(1) Type "K" hard or soft copper tubing with wrought copper fittings and brazed joints. There shall be no joints beneath slabs.

G. Hydronic Piping (Hot)

(1) 2" and Smaller: Schedule 40 black steel pipe with screwed fittings or Type "L" hard copper tubing with wrought copper fittings and 95/5 solder.

(2) 2-1/2" and Larger: Schedule 40 black steel pipe with 125# welded or flanged joints. Weldolets may be used for branch line connections to pipe mains. Type "L" hard copper piping with wrought copper fittings and 95/5 solder may be installed.

(3) Schedule 40 Victaulic 107/W07 or engineer approved equivalent mechanical grooved pipe couplings and fittings with 125# rating minimum may be used. Install gaskets as recommended by the manufacturer. Piping system shall be rated for minimum of 250°F water temperature. Mechanical grooved piping may not be used if system water temperature exceeds 250°F.

   a. Roll grooves in ends of pipe based on pipe and coupling manufacturer’s written instructions, which may or may not include torque settings, torque wrenches, extreme lubricant and specified gaps. Engineer reserves the right to inspect any and all installation of product. Factory trained representative must periodically visit the job site and provide on-site training. Grooved pipe shall be produced using the RG5200i/5200i fully automated grooving tool, where applicable, that provides groove traceability documents, corresponding identification marks on the pipe, and
confirm all critical dimensions fall into the required tolerance range as listed by the tool manufacturer.

(4) Special Notes:

a. Dielectric unions shall be provided at all connections of dissimilar materials.

b. Copper and steel piping shall not be mixed in the mechanical room.

c. Piping shall meet all State Boiler Code requirements. Pay particular attention to welded pipe requirements for hot water systems.

d. Takeoffs and branch piping to individual coils or heat pumps shall not be connected to the bottom of hydronic mains. Connection to mains shall be at the side of the main. Also refer to details on the drawings.

H. Air Vent Discharge Lines

Type "L" soft copper; wrought copper fittings, 95/5 solder.

I. Refrigerant Piping

Interior Piping for Variable Refrigerant Flow Systems 1/8” to 1-3/8” shall be ACR soft copper tube with long radius bends of soft copper tube. Provide ACR hard copper tube in all sizes for systems other than Variable Refrigerant Flow. Interior lines larger than 1-3/8” shall be ACR hard copper tube. All exterior lines shall be ACR hard copper tube. Fitting shall be wrought or forged copper with silver solder joints and minimum 15% silver content.

(2) General Installation Notes:

a. Contact Engineer 24 hours prior to installation of refrigerant lines or evacuation of refrigerant system.

b. Refrigerant lines installation must meet HVAC equipment manufacturer's recommendations.

c. While installing or soldering refrigerant lines, system must continuously be purged with nitrogen.

d. After system is installed, the refrigerant system must be evacuated to 25 microns for eight hours.

J. Condensate Drain Lines

(1) Type "DWV" copper, wrought copper, lead free solder.
(2) Schedule 40 PVC with solvent welded fittings.

K. Water Heater Relief Line

Type "M" copper tubing with sweat fittings and 95/5 solder.

L. LP Gas Piping

Same as specified for natural gas piping.

M. RADIANT PIPING

1. GENERAL

A. SECTION INCLUDES

(1) Radiant floor heating and snow melting systems for various applications and control strategies, using cross-linked polyethylene (PEX) tubing and appropriate fittings.

B. RELATED SECTIONS

(1) Section 02551 – Underground Hydronic Piping
(2) Section 03300 – Concrete
(3) Section 06100 – Rough Carpentry
(4) Section 07210 – Insulation
(5) Section 15093 – Sleeves and Sleeve Seals for HVAC Piping
(6) Section 15181 – Hydronic Piping

C. REFERENCES

(1) General: Standards listed by reference, including revisions by issuing authority, form a part of this specification section to the extent indicated. Standards listed are identified by issuing authority, authority abbreviation, designation number, title or other designation established by issuing authority. Standards subsequently referenced herein are referred to by issuing authority abbreviation and standard designation.

(2) Certified to ASTM International by NSF:

(3) Certified to ASTM International, UL, NFPA and ULC by Intertek:


(4) Certified to Canadian Standards Association (CSA) by NSF:

a. CAN/CSA B137.5 Cross-linked Polyethylene (PEX) Tubing Systems for Pressure Applications.

(5) Certified to International Code Council (ICC) by NSF:

a. International Mechanical Code (IMC)

b. International Building Code (IBC)

(6) Certified to International Association of Plumbing and Mechanical Officials (IAPMO) by NSF:

a. Uniform Mechanical Code (UMC)

(7) German Institute for Standards (Deutsches Institut fur Normung e.V., DIN):

a. DIN 4726 Pipelines of Plastic Materials Used in Warm Water Floor Heating Systems; General Requirements

(8) International Association of Plumbing and Mechanical Officials (IAPMO):

a. Certificate of Listing

(9) National Sanitary Foundation (NSF) International:

a. NSF – PW (Potable Water)

b. NSF – RFH (Radiant Floor Heating)

c. NSF CL – TD and CL – R (as specified in NSF Protocol P – 171)

(10) Plastics Pipe Institute (PPI)


b. Technical Report TR – 4 Recommended Hydrostatic Strengths and Design Stresses for Thermoplastic Piping and Fitting Compounds

(11) Watts Radiant


b. RadiantWorks Professional Software

D. SYSTEM DESCRIPTION

(1) Design Requirements:

a. Cross-linked Polyethylene Tubing (PEX): Standard Grade hydrostatic pressure ratings from Plastics Pipe Institute in accordance with TR-3 as listed in TR-4. The following three standard-grade hydrostatic ratings are required:

1) 200 degrees F (93 degrees C) at 80 psi (551 kPa).
2) 180 degrees F (82 degrees C) at 100 psi (689 kPa).
3) 73.4 degrees F (23 degrees C) at 160 psi (1102 kPa).

(2) Performance requirements: Provide Hydronic system that is manufactured, fabricated and installed to comply with regulatory agencies and authorities with jurisdiction, and maintain performance criteria stated by the tubing manufacturer without defects, damage, or failure.
   a. Cross-linked Polyethylene Tubing (PEX):
      1) Show compliance with ASTM F877
      2) Show compliance with DIN 4726 regarding oxygen diffusion concerns where applicable.
      3) Show compliance with NFPA 90A requirements of flame spread/smoke development rating of 25/50 in accordance with ASTM E84 through certification listings with Intertek.
      4) Show compliance with ASTM E119, UL 263, NFPA 251, and CAN/ULC S101 through certification listings with Intertek:
         (a) Intertek Design No. WR/WA 60-01: 1 hour wood or steel stud/gypsum wallboard wall assembly.
         (b) Intertek Design No. WR/FCA 60-01: 1 hour wood frame floor/ceiling assembly
         (c) Intertek Design No. WR/FCA 120-01: 2 hour concrete floor/ceiling assembly

E. SUBMITTALS

(1) General: Submit listed submittals in accordance with Conditions of the Contract and Division 1 Submittal Procedures Section.
(2) Product Data: Submit manufacturer’s product submittal data and installation instructions for each product.

(3) Shop Drawings – Hydronic System
   a. Provide engineering analysis using manufacturer’s proprietary software.
   b. Provide installation drawings indicating tubing layout, manifold locations, zoning requirements, and manifold schedules with details required for installation of the system.
   c. Provide mechanical schematic indicating heat source, mechanical piping and accessories from heat source to manifolds, circulators, water tempering, and zone controls. Indicate supply water temperatures and flow rates to manifolds.

(4) Samples: Submit selection and verification samples of primary materials.

(5) Documentation:
   a. Provide manufacturer’s detailed instructions for site preparation and product installation.
   b. Provide manufacturer’s electrical power requirements and heat output in watts delivered to the structure.
   c. Provide documentation indicating the installer is trained to install the manufacturer’s products, as needed.
(6) Quality Assurance and Control Submittals:
   a. Upon request, submit test reports from recognized testing laboratories.

(7) Closeout Submittals – Submit the following:
   a. Warranty documents specified
   b. Operation and maintenance data
   c. Manufacturer’s field reports as specified in this document
   d. Final as-built tubing layout drawing

F. QUALITY ASSURANCE

(1) Manufacturer Qualifications:
   a. Manufacturer shall have a minimum of ten years experience in similar systems.
   b. Manufacturer shall provide products of consistent quality in appearance and physical properties.
   c. Manufacturer shall use the highest quality products in the production of systems and components referenced in this document.
   d. Materials shall be from a single manufacturer to ensure consistent quality and compatibility.

(2) Installer Qualifications:
   a. Use and installer with demonstrated experience on projects of similar size and complexity and/or documentation proving successful completion of familiarization training hosted/approved in writing by the system manufacturer.
   b. Electrical rough-in and connections shall be done by a licensed electrician.

(3) Certifications: Provide letters of certification as follows:
   a. Installer employs skilled workers holding a trade qualification license or equivalent, or apprentices under the supervision of a licensed trades person.

(4) Regulatory Requirements and Approvals – Hydronic Systems: Provide a radiant system that complies with the following requirements:
   a. International Code Council (ICC):
      1) International Mechanical Code (IMC)
      2) International Building Code (IBC)
      3) ICC Evaluation Service (ES) Evaluation Report No. ESR 1155
   b. International Association of Plumbing and Mechanical Officials (IAPMO):
      1) Uniform Mechanical Code (UMC)

(5) Pre-installation meetings
   a. Verify project requirements, substrate conditions, excavation conditions, system performance requirements, coverings, manufacturer’s installation instructions, and warranty requirements.
   b. Review project construction timeline to ensure compliance or discuss modifications as required.
   c. Coordinate with other trade representatives to verify areas of responsibility.
d. Establish the frequency (during construction phase of the project) the engineer intends for site visits and inspections by the manufacturer’s representative.

(6) Mock-up: Provide a mock-up for evaluation of surface preparation techniques and application workmanship.
   a. Finish areas designated by Architect
   b. Do not proceed with remaining work until workmanship, color, and sheen are approved by Architect.
   c. Refinish mock-up area as required to produce acceptable work

G. DELIVERY, STORAGE, AND HANDLING

   (1) General: Comply with Division 1 Product Requirements Section.
   (2) Comply with manufacturer’s ordering instructions and lead-time requirements to avoid construction delays.
   (3) Deliver materials in manufacturer’s original, unopened, undamaged containers with identification labels intact.
   (4) Store materials protected from exposure to harmful environmental conditions and at temperature and humidity conditions recommended by the manufacturer:
      a. Store tubing in cartons or under cover to avoid dirt or foreign material from entering the tubing.
      b. Do not expose tubing to direct sunlight for more than 30 days. If construction delays are encountered, cover the tubing that is exposed to direct sunlight.

H. PROJECT CONDITIONS

   (1) Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer’s absolute limits.
   (2) Morter-set Systems: Mortar shall cure for 25 days (or time specified by mortar manufacturer) prior to starting heating systems.

I. WARRANTY

   (1) Project Warranty: Refer to Conditions of the Contract for project warranty provisions.
   (2) Manufacturer’s Warranty – Hydronic Systems
      a. Submit, for Owner’s acceptance, manufacturer’s standard warranty document executed by authorized company official.
      b. Manufacturer’s warranty is in addition to, and not a limitation of, other rights Owner may have under contract documents.
         1) Warranty covers the repair or replacement of any tubing or fittings proven defective.
         2) Warranty may transfer to subsequent owners.
3) Warranty Period for Tubing is 25-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of substantial completion.

4) Warranty Period for Manifolds and Fittings is 2-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of substantial completion.

5) Warranty period for Controls and Electrical components is a 2-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of substantial completion.

J. SYSTEM START-UP
(1) Do not start the system for a minimum of 25 days or as specified by mortar, concrete and/or covering manufacturer as applicable.

(2) Verify all electrical components are installed per local and National Electrical Code (NEC) prior to start-up.

K. OWNER’S INSTRUCTIONS
(1) Instruct Owner about operation and maintenance of installed system.

(2) Provide Owner with manufacturer’s installation instructions for installed components within the system.

(3) Provide Owner with all operating instructions/documents for sensors and controls.

(4) Provide Owner with copies of any detailed layout drawings and photos of installed product before coverings are installed.

2. PRODUCTS

A. MANUFACTURERS
(1) Acceptable Manufacturer:
Watts Radiant, Inc.
(Subsidiary of Watts Water Technologies, Inc.)
4500 E. Progress Place
Springfield, MO 65803
(800) 276-2419; (417) 864-6108; Fax: (417) 864-8161
Web: http://www.wattsradiant.com

B. PRODUCT CHARACTERISTICS
(1) Material:
a. Cross-linked polyethylene (PEX)
b. Manufactured by PEX-b or Silane method to ensure the highest level of oxidation protection.
(2) Material Standard:
   a. Manufactured in accordance with ASTM F876 and ASTM F877
   b. Tested for compliance by an independent third-party agency.

(3) Pressure Ratings:
   a. Standard Grade hydrostatic design
   b. Pressure ratings as issued by the Plastics Pipe Institute (PPI), a division of the Society of the Plastics Industry (SPI).

(4) Temperature/Pressure Ratings: shall be capable of withstanding temperatures of:
   a. 73.4°F (23°C) at 160 psi (1.10 MPa)
   b. 180°F (82.2°C) at 100 psi (0.69 MPa)
   c. 200°F (93.3°C) at 80 psi (0.55 MPa).

(5) Minimum Bend Radius (Cold Bending):
   a. No less than six times the outside diameter.
   b. Use the tubing manufacturer’s bend supports if radius is less than stated.

(6) Barrier Tubing Type: Watts Radiant RadiantPEX+
   a. Oxygen Diffusion Barrier
      1) Tubing has an oxygen diffusion barrier that shall not exceed an oxygen diffusion rate of 0.10 g/cubic meter (.000062 lb/cu. ft.) per day at 104 degrees F (40 degrees C) water temperature in accordance with German DIN 4726.
      2) Tubing also adds a protective polypropylene layer to the outside of the EVOH barrier.
   b. Nominal Inside Diameter: Provide tubing with nominal inside diameter in accordance with ASTM F876, as indicated:
      1) ⅜ inch (9.53 mm)
      2) ½ inch (12.7 mm)
      3) ⅝ inch (15.88 mm)
      4) ¾ inch (19.05 mm)
      5) 1 inch (25.4 mm)

(7) Barrier Tubing Type: Watts Radiant RadiantPEX
   a. Oxygen Diffusion Barrier
      1) Tubing has an oxygen diffusion barrier shall not exceed an oxygen diffusion rate of 0.10 g/cubic meter (.000062 lb/cu. ft.) per day at 104 degrees F (40 degrees C) water temperature in accordance with German DIN 4726.
   b. Nominal Inside Diameter: Provide tubing with nominal inside diameter in accordance with ASTM F876, as indicated:
      1) 1¼ inch (31.75 mm)
      2) 1½ inch (38.1 mm)
      3) 2 inch (50.8 mm)

(8) Non-Barrier Tubing Type: Watts WaterPEX
   a. Watts WaterPEX tubing does not feature an oxygen diffusion barrier.
b. Nominal Inside Diameter: Provide tubing with nominal inside diameter in accordance with ASTM F876, as indicated:
   1) ⅜ inch (9.53 mm)
   2) ½ inch (12.7 mm)
   3) ⅝ inch (15.88 mm)
   4) ¾ inch (19.05 mm)
   5) 1 inch (25.4 mm)
   6) 1¼ inch (31.75 mm)
   7) 1½ inch (38.1 mm)
   8) 2 inch (50.8 mm)

c. An oxygen diffusion barrier tubing is not required if one of the following design strategies is used:
   1) Isolate the ferrous materials in the boiler and other components within the primary side of the mechanical system with a heat exchanger.
      i. Use non-ferrous components within the secondary system side (e.g., pumps, expansion tanks, etc.).
   2) Use non-ferrous components within the entire fluid pathway.

9) Use Watts Radiant RadiantPEX or RadiantPEX+ tubing when oxygen diffusion barrier tubing is required. Use Watts WaterPEX when non-barrier tubing is required.

C. MANIFOLDS AND FITTINGS

1) Manifolds (Residential and light Commercial, Stainless Steel)
   a. For system compatibility, use 1” Stainless Steel manifolds offered by the respective tubing manufacturer.
   b. Manifolds shall provide individual flow control for each loop of the manifold through valve actuators available from the manifold supplier.
   c. Manifolds shall feature manual flow balancing capability within the manifold body for balancing unequal loop lengths across the manifold. Balance valves shall not be ball valves.
   d. Manifolds accommodate ⅜ - ¾” (9.5 – 19 mm) RadiantPEX+ tubing.
   e. Each manifold location shall have the ability to vent air manually from the system.
   f. Stainless Steel 1” (25 mm) Manifolds
      1) Heavy-duty, DIN Standard, 304 stainless steel
      2) Matching fittings and accessories are made of solid brass and are heavily plated with nickel to match the appearance of the manifold trunk.
      3) Internal balancing valves
      4) 0 - 2½ gpm (0 – 0.16 L/sec) flow meters
      5) Manifold brackets
      6) All connections are BSP (British Standard Pipe) or straight thread and require the use of the included gasket.
      7) 2½” (54 mm) OC circuit spacing
      8) 12 gpm (.75 L/sec) maximum flow rate
      9) 194°F (90°C) maximum operating temperature
      10) 87 psi (600 kPa) maximum operating pressure
      11) 2½ gpm (0.16 L/sec) per circuit maximum flow rate
(2) Manifolds (Commercial, Copper)
   a. Provide 1” (25 mm) or larger Copper manufactured from L-copper and offered by the respective tubing manufacturer for system compatibility.
      1) Install manifolds with optional isolation valves located on both the supply and return manifold.
      2) Each manifold location shall have the ability to vent air manually from the system.
   b. Provide Copper manifolds approved for use in systems free of ferrous materials, or isolate ferrous material to eliminate corrosion damage due to oxygen diffusion.
   c. Balancing:
      1) Design individual loop lengths across the manifold with 10% of each other in length.
      2) Install supply and return piping to the manifold in a reverse-return configuration to ensure self-balancing.
      3) Where the supply and return piping is in direct-return configuration, use manifolds with balancing valves or balance flow setters on the return leg of each manifold to the mains.

(3) Manifold Mounting Boxes
   a. Sizes – Watts Radiant manifold mounting boxes come in 3 sizes:
      1) 15¾” by 28½” by 4¼”
      2) 24½” by 28½” by 4⅜”
      3) 39½” by 28½” by 4⅜”
   b. Each box shall be designed to be recessed into a 4” or 6” (102 mm or 152 mm) stud wall.
   c. Included elevators can raise the box from 1½” to 4½” (38 – 114 mm) off of the floor.
   d. Each manifold box is constructed of powder-coated sheet metal, providing increased resistance to corrosion and job-site abuse.
   e. Inside Manifold Mounting Brackets:
      1) Manifold boxes come with 2 fixed horizontal attachment rails and 2 adjustable rails.
      2) Each Watts Radiant manifold option will utilize different rail positions, depending on the bracket used.

(4) Fittings
   a. For system compatibility, use fittings offered by the tubing manufacturer.
      1) The fitting assembly shall comply with ASTM F877 and CAN/CSA B137.5 requirements.
      2) Fittings shall be designed to work with either ASTM F1807 Crimp Rings or ASTM F2098 Cinch Clamps or a Compression ferrule, and are designed to be used with ASTM F876 (SDR-9) rated PEX tubing.
      3) Available connections:
         (a) Sweat
         (b) NPT
         (c) BSP
   4) Material:
      (a) UNS 31400 Copper Alloy
      (b) UNS 36000 Copper Alloy
D. SUPPLY AND RETURN PIPING

(1) Supply-and-Return Piping to the Manifolds (above ground piping):
   a. Properly size supply and return distribution piping for the given volume and velocities required at system design.
   b. Use compatible distribution pipe material for all supply fluid temperatures and flows in systems with ferrous components.
      1) When using Watts Radiant RadiantPEX tubing, do not exceed 200 degrees F (93 degrees C) at 80 psi (551 kPa).
      2) When using Watts Radiant RadiantPEX+ tubing, do not exceed 200 degrees F (93 degrees C) at 80 psi (551 kPa).
   c. Use suitable distribution piping material (i.e., Watts WaterPEX or HDPE) for systems free of or isolated from ferrous components.
      1) When using HDPE mains, do not exceed 140 degrees F (60 degrees C) at 80 psi (551 kPa).
      2) When using Watts WaterPEX mains, do not exceed 200 degrees F (93 degrees C) at 80 psi (551 kPa).
   d. Do not expose Watts Radiant RadiantPEX, Watts Radiant RadiantPEX+, or Watts WaterPEX tubing to direct sunlight.
      1) Where PEX tubing is exposed, install suitable pipe insulation around the exposed tubing.
   e. Use fittings compatible with piping material. Fittings shall transition from distribution piping to system manifolds.

(2) Supply and Return Piping to the Manifolds (below ground piping):
   a. Properly size supply and return distribution piping for the given volume and velocities required at system design.
   b. Use suitable distribution piping material for all supply fluid temperatures and flows in systems with ferrous components.
      1) When using Watts Radiant RadiantPEX tubing, do not exceed 200 degrees F (93 degrees C) at 80 psi (551 kPa).
      2) When using Watts Radiant RadiantPEX+ tubing, do not exceed 200 degrees F (93 degrees C) at 80 psi (551 kPa).
   c. Use suitable distribution piping material (i.e., Watts WaterPEX or HDPE) for systems free of or isolated from ferrous components.
      1) When using HDPE mains, do not exceed 140 degrees F (60 degrees C) at 80 psi (551 kPa).
      2) When using Watts WaterPEX mains, do not exceed 200 degrees F (93 degrees C) at 80 psi (551 kPa).
   d. Use fittings compatible with piping material. Fittings shall transition from distribution piping to system manifolds.

E. ROOM TEMPERATURE CONTROLS

(1) Room Temperature Controls:
   a. Thermostat: Digital, programmable, air, 24V
b. All thermostats shall operate within a one degree differential temperature incorporating pulse-width modulation action.

c. Install a Watts Radiant Thermostat (heat only) with digital display in each room or zone as required.
   1) The Watts Radiant Dual Temp thermostat shall have the ability to sense the temperature of the air, floor, or a combination of air and floor.
   2) Each Dual Temp shall be equipped with an internal air sensor.

d. For multiple-zoning control, install the loop(s) per zone and install the individual valve actuators on the respective loop(s) at the manifold.
   1) Electro-thermal Actuators
      (a) Watts Radiant Thermal Actuators are a four-wire actuator designed for use with Watts Radiant Stainless Steel manifolds.
         i. Actuators are normally closed and will open when power is applied.
         ii. Actuators shall consume no more than 2.5 watts.
         iii. Travel time for the actuators is approximately 90 seconds to close the end switch.
         iv. Each actuator consists of 4 wires, 2 for power and 2 for an end switch.
   2) Zone Valve Actuator Control Module: Zone valve actuator controls operate zone valves or circuit thermal actuators by supplying 24VAC.
      (a) No more than three 2.5 VA actuator valves can be connected to any single zone terminal block.
      (b) The control system shall be designed for use with the following models of thermostats:
         i. Watts Radiant Dual Temp (3 or 4 wire)
         ii. Watts Radiant Air Only thermostats
         iii. Use only Watts Radiant non-programmable thermostat if using Optional Timer
         iv. Any 2 wire thermostats with internal battery power
         v. 2 wire thermostats that consume power shall not be used, as damage to either the thermostat or controller may occur.
            a) Never connect a power consuming 2 wire thermostat to the control as damage to the thermostat and/or control may occur.
      (c) External 24/120 VAC transformer (not included) is required to operate these controls.
         i. A 40 VA transformer for a maximum of 12 actuators
         ii. A 60 VA transformer for a maximum of 18 actuators
      (d) Master Controls:
         i. Equipped with valve and thermostat terminals
         ii. Incoming 24 volt power connection
         iii. Two 8 amp, dry contact terminals for pump and boiler operation
            a) With end-switch capability, the Zone Control Module activates other relays
or controls as required by system control strategy.

b) Control does not use the end-switch wires of a 4 wire actuator

c) Both 2 wire and 4 wire actuators may be used.

(e) Slave Controls:

i. The use of Slave units allows the control of more zones utilizing the same pump and boiler.

ii. Up to 2 Slave controls can connect to a Master

   a) Allows for a maximum of 18 separate zones or thermostat connections

   b) Both 2 wire and 4 wire actuators may be used.

F. ACCESSORIES

(1) Provide accessories associated with the installation of the radiant heating system as recommended by or available from the tubing manufacturer.

a. IsoTherm: The IsoTherm provides mixing control and zone pumping all in a compact, unique package that conveniently connects directly to Watts Radiant Stainless Steel manifolds.

   1) The IsoTherm module includes the following items:

      (a) Mix Valve

      (b) 3 speed 1/25 hp Circulator

      (c) Temperature Gauge

      (d) Maximum Temperature Sensor

      (e) Trunk Isolation Valves

      (f) BSP to NPT Transition Nipple

   2) Mounting:

      (a) The IsoTherm can be wall mounted with standard cushion clamps or other copper pipe mounted brackets.

      (b) The IsoTherm can be integrated into a standard Watts Radiant manifold box.

b. Pressure Differential By-pass Valve (for use with 1” Stainless Steel Manifolds only):

   1) Use Watts Radiant Pressure Differential By-pass Valve with the manifolds incorporating actuators to avoid noise due to excessive water velocity.

      (a) Eliminates water velocity noise and water hammer.

      (b) Increases pump life because of minimal pressure surging as actuators open and close.

      (c) There is always correct and constant flow regardless of the number of actuators or zone valves open.

      (d) Water flow through the DBP valve shall be 25-30 % of the total flow:

         i. The over-pressure shall not exceed 10-15 % of the system pressure drop.

         ii. If the zones to be by-passed have a maximum pressure drop of 0.5 psi (3.5 kPa), the DBP valve shall be set to accommodate this pressure plus 10-15 %.
iii. The DBP valve needs to be installed ‘downstream’ of the main circulator.
iv. Install before the system zones
v. Should connect the supply line with the return line
c. FlowGuard:
   1) FlowGuards shall be of commercial-quality, non-electronic flow indicator and flow setter.
   2) Cast brass construction
   3) Accurate visual flow indication in GPM
   4) Ability to set fluid flow
   5) FlowGuards shall allow zone-by-zone control and optimization.
   6) No special training or electronic instrumentation required,
   7) Sizes:
      (a) 1” (25 mm) MNPT ends: 0.5 – 4 gpm (0.03 to 0.25 L/sec) flow meter
      (b) 1” (25 mm) FNPT ends: 1 – 13 gpm (0.06 to 0.8 L/sec) flow meter
d. Tempering Valves:
   1) MixTemp 180 Mixing Valve:
      (a) The MixTemp 180 is a 3 port, non-electric nix valve for use in Hydronic heating systems.
         i. Hot, cold, and mix ports are clearly marked “H,” “C,” and “M.”
      (b) This mix valve shall be capable of delivering water temperatures ranging from 90° to 160°F (32° to 71°C) +/- 3° F.
      (c) The Hydronic mix valve shall have a cast bronze body.
      (d) Copper, stainless steel and EPDM internal parts
      (e) There are no ferrous components to corrode.
      (f) The actuator for the piston shall have lineal expansion characteristics, and shall be completely filled with a temperature-sensitive wax.
      (g) Each port on the MixTemp has a union to allow for easy servicing
      (h) Available in ¾” (19 mm) and 1” (25 mm) female NPT fittings.
         i. ¾” Cv = 3.1 gpm (0.195 L/sec)
         ii. 1” Cv = 3.2 gpm (0.20 L/sec)
      (i) These mixing valves are not anti-scald valves since they do not have positive shut-off in case of failure of hot or cold water supply. We do not recommend their use for shower service.
      (j) Shall have a source of return water cooler than the desired mix temperature to operate properly.
      (k) The mix valve shall not be heated in excess of 200°F (93°C) to prevent the liquid-filled actuator from rupture.
         i. To prevent damage, temporarily remove the mixing valve from the unions before soldering near the mix valve.
   2) AllTemp Mixing Valve:
      (a) The AllTemp shall be a non-electric, 3 port mix valve for use in Hydronic heating systems.
      (b) Valve shall be capable of delivering water temperatures ranging from 100 – 200°F (38 – 93°C).
      (c) The hydronic mix valve shall have a cast bronze body.
      (d) Chrome-plated bronze piston
(e) The actuator for the piston shall have linear expansion characteristics, and shall be completely filled with a temperature-sensitive liquid communicating with the hydraulically formed NPT fittings.

(f) The AllTemp is available in 1¼” (32 mm), 1½” (38 mm), and 2” (51 mm) female NPT fittings.
   i. 1¼” Cv = 6.1 gpm (0.38 L/sec)
   ii. 1½” Cv = 6.2 gpm (0.39 L/sec)
   iii. 2” Cv = 9.1 gpm (0.6 L/sec)

(g) Mixing valves are not anti-scald valves since they do not have positive shut-off in case of failure of hot or cold water supply. Do not use for shower service.

(h) Shall have a source of cooler return water to operate properly.

(i) The mix valve shall not be heated in excess of 230°F (110°C), or the liquid-filled actuator may rupture.
   i. To prevent damage, temporarily remove the actuator assembly from the valve body before soldering near the mix valve.

3. EXECUTION

A. EXAMINATION

   (1) Site Verification of Conditions:
      a. Verify that site conditions are acceptable for installation of the system. Refer to manufacturer’s installation manual for information.
      b. Do not proceed with installation of the system until unacceptable conditions are corrected.

B. INSTALLATION OF FLOOR HEATING SYSTEMS

   (1) Refer to attached manufacturer’s instructions. Comply with manufacturer’s product data, including product technical bulletins, installation instructions and design drawings, including the following:
      a. Installation manuals
      b. Design software engineering and analysis

   (2) Slab-On-Grade Installation:
      a. Fasten the tubing to the flat mesh or reinforcing bar in accordance with the tubing manufacturer’s installation recommendations.
      b. Use closer tubing on-center distances along exterior walls. Increase tubing on-center distances as the installation moves away from the exterior wall as determined by manufacturer analysis.
      c. Staple the tubing to the insulation board.
      d. Install edge insulation where the heated panel directly contacts an exterior wall or panel.
      e. Install tubing at a consistent depth below the surface elevation. Ensure sufficient clearance to avoid control joint saw cutting.
f. Where tubing crosses metal expansion joints in the concrete, ensure the tubing passes below the joints or is sleeved through the joint.

(3) Pre-Cast Plank Construction with a Cap Pour:
   a. Fasten the tubing to the flat mesh or reinforcing bar, or snap into Triple-track or Single-track RailWays in accordance with the tubing manufacturer’s installation recommendations.
   b. Use closer tubing on-center distances along exterior walls. Increase tubing on-center distances as the installation moves away from the exterior wall.
   c. Staple the tubing to the insulation board.
   d. Install edge insulation where the heated panel directly contacts an exterior wall or panel.
   e. Install tubing at a consistent depth below the surface elevation. Ensure sufficient clearance to avoid control joint saw cutting.
   f. Where tubing crosses metal expansion joints in the concrete, ensure the tubing passes below the joints or is sleeved through the joint.

(4) Wood Floor Construction with a Lightweight Gypsum Topping:
   a. Staple tubing to the wood sub-floor in accordance with the tubing manufacturer’s installation recommendations. The attachment method shall not cause abrasions on the tubing.
   b. Use closer tubing on-center distances along exterior walls. Increase tubing on-center distances as the installation moves away from the exterior wall.
   c. Ensure the depth of the lightweight pour is a minimum of ¾” (19 mm) over the outside dimension of the tubing, 1” typical overall thin-slab thickness.
   d. Install reinforcing mesh within the pour for finished flooring of tile or linoleum.
   e. Install wood sleepers along the room perimeter and between the tubing to provide a nailing surface for finished wood floors or carpet tack strips as required. Refer to Section 06100.
   f. Allow lightweight gypsum concrete pour to cure in accordance with the applicator’s instructions. Once cured, seal the surface of the floor topping to protect surface from moisture.
   g. Install insulation in the joist cavity below the floor in accordance with the submitted radiant floor design. Refer to Section 07210.
   h. Install edge insulation if the heated panel directly contacts an exterior wall or panel. Refer to Section 07210.

(5) Wood Floor Construction with UnderFloor Heating (Onix tubing attached directly to wood sub-floor):
   a. Install tubing attached directly to the underside of the wood sub-floor in accordance with the tubing manufacturer’s recommendations. The attachment method shall not puncture or cause abrasions to the tubing.
   b. Do not exceed 8” (203 mm) on center tube spacing. Refer to the submitted radiant floor design.
   c. Comply with the tubing manufacturer’s installation procedures on proper joist drilling.
d. Install foil-faced insulation in the lower portion of the joist cavity. Allow an air gap of 2 – 3” (51 – 76 mm) between the wood sub-floor and the top of the insulation. Refer to Section 07210.

e. Use the recommended amount of insulation in the joist cavity below the floor in accordance with the submitted radiant floor design. Refer to Section 07210.

f. Use edge insulation equal to the amount of underfloor insulation if the heated panel directly contacts an exterior wall or panel. Refer to Section 07210.

(6) Wood Floor Construction with Joist Heating (tubing suspended in the joist bay):

a. Install tubing within the joist cavity in accordance with the tubing manufacturer’s recommendations. The attachment method shall not cause abrasions to the tubing.

b. Do not exceed 8” (203 mm) on center. Refer to the submitted radiant floor design.

c. Do not allow tubing within the joist cavity to contact the wood sub-floor.

d. Refer to the tubing manufacturer’s installation procedures on proper joist drilling.

e. Install foil-faced insulation in the lower portion of the joist cavity. Allow an air gap of 2 – 3” (51 – 76 mm) between the wood sub-floor and the top of the insulation. Refer to Section 07210.

f. Use the recommended amount of insulation in the joist cavity below the floor in accordance with the submitted radiant floor design. Refer to Section 07210.

g. Use edge insulation equal to the amount of underfloor insulation if the heated panel directly contacts an exterior wall or panel. Refer to Section 07210.

(7) Wood Floor Construction with SubRay:

a. Install SubRay on top of the wood sub-floor according to the tubing manufacturer’s instructions.

b. Coordinate the finished floor covering layout direction with the direction of the SubRay layout. Comply with the tubing manufacturer’s instructions.

c. Install insulation in the joist cavity below the floor according to the submitted radiant floor design. Install the insulation tight against the wood sub-floor. Refer to Section 07210.

d. Use the recommended amount of insulation in the joist cavity below the floor in accordance with the submitted radiant floor design. Refer to Section 07210.

e. Use edge insulation equal to the amount of underfloor insulation if the heated panel directly contacts an exterior wall or panel. Refer to Section 07210.

C. FIELD QUALITY CONTROL AND TESTING

(1) Site tests:

a. To ensure system integrity, pressure test the system before covering tubing in concrete or when other trades are working in the vicinity of the tubing.

b. Test all electrical controls in accordance with respective installation manuals.

c. System shall be checked after 3 years of operation and every year thereafter. System shall be checked for pH levels to ensure that it is operating within suggested guidelines.

D. SYSTEM ADJUSTING
(1) Balancing Across Manifold: Balance all loops across each manifold for equal flow
resistance based on actual loop lengths and total manifold flow.

(2) Balancing between manifolds is accomplished with a flow control device installed on the
return piping leg from each manifold when direct return piping is used for the supply and
return mains or the circuits deviate by more than 10%.

E. CLEANING

(1) Remove temporary coverings and protection of adjacent work areas.

(2) Repair or replace damaged installed products.

(3) Clean installed products in accordance with manufacturer’s instructions prior to Owner’s
acceptance.

(4) Remove construction debris from project site and legally dispose of debris.

F. DEMONSTRATION

(1) Demonstrate operation of system to Owner or Owner’s personnel.

(2) Instruct the Owner or Owner’s personnel about the type, concentration and maintenance
of the glycol and water solution.

(3) Provide Owner or Owner’s personnel with manufacturer’s installation, operation, and
maintenance instructions for installed components within the system.

G. PROTECTION

(1) Protect installed work from damage caused by subsequent construction activity on the
site. Provide Owner with copy of photos and drawings of product locations to assist.

END OF SECTION 15100
Walls and Ceilings

Installation Method 2
(Any Tubing)

1. Install foil-faced insulation with the foil facing the heated space.
2. Install a layer of 1/2” plywood on top of the studs or joists.
3. Install SmartTrac on top of the plywood in the same fashion as described in the SmartTrac installation manual. If installing a radiant wall, run the Header Sticks vertically along the sides of the wall. It may be necessary to use more Grippers than what would normally be used for a SmartTrac floor application, especially when installing a radiant ceiling.

Install Method 3
(Any Tubing)

1. Install foil-faced insulation with the foil facing outward, or downward, towards the room.
2. Install 3/4” sleepers perpendicular to studs, 1-1/4” apart.
3. Install rolled heat transfer plates between sleepers.
4. Install tubing in plate.

**NOTICE**

When using rolled plates, it is sometimes beneficial to place a bead of silicone in the channel prior to installing the tubing.

Installation Method 4
(RadiantPEX-AL Only)

1. Install foil-faced insulation with the foil facing the heated space.
2. Lay poultry netting (chicken wire) across the studs. Allow enough slack in the netting to push the tubing flush, but in contact, with the drywall.
3. Attach the RadiantPEX-AL to the netting with the use of cable ties.
4. Lay the drywall over the RadiantPEX-AL.

Inspection and pressure testing for wall and ceiling applications are the same as described in the UnderFloor section.

Slab Application

Slab applications are one of the most common applications used in commercial, as well as some residential, radiant heating systems.

Since the slab is generally in direct contact with the ground, energy can be rapidly lost to the surroundings. To help reduce these back and edge losses, certain conditions must be met prior to the radiant installation to help ensure proper system operation.

Site Preparation

A radiant slab should be placed on well drained base rock material. Sub-surface water will rob heat from a radiant slab faster than a boiler can produce it. Basements and slabs installed in hillsides should have good drainage to carry any subsurface groundwater away from the site. The slab should be placed above an ample amount of crushed rock or gravel.

Radiant slabs placed on low-lying, poorly drained soil or sand should have at least one inch (minimum of R-5) of extruded polystyrene (Dow® Blue Board®) or equivalent insulation under the entire slab—even in southern climates.
A radiant slab should never be placed directly on top of clay or organic subsoil, as these materials can conduct heat away from the radiant slab, and the soils may shrink in volume when directly exposed to the heat of the slab. An intervening layer of four or more inches of crushed rock or river gravel should be used.

A radiant slab should never be placed directly on top of solid bedrock, as this material can rapidly conduct heat from the slab into the earth. Crushed rock and insulation must be installed between the slab and rock.

In some cases, one to two inches of sand may be placed on top of the coarser base rock material. This gives a smooth, level surface to lay down rigid insulation, and helps prevent possible damage to the rigid insulation in high traffic areas prior to concrete placement. The sand layer also allows for more precise leveling to minimize any variation in the slab thickness.

**NOTICE**

Check with local building codes to see if they allow the use of sand directly underneath slabs.

**Insulation Requirements**

Unlike a frame application where the insulation is installed after the radiant tubing, a slab application requires the insulation to be installed first, making the insulation part of the structure.

In a slab on grade application there are two main areas to insulate: vertically around the perimeter of the slab and horizontally underneath the slab. Both will aid in the slab’s response and efficiency. Of these two, the vertical edge insulation is the most important because it prevents heat loss directly to the outside environment. Horizontal insulation helps decrease the slabs required start up time by isolating the heating mass from the ground mass below.

Typically the system will see a reduction of about 10-20% in overall operational efficiency if horizontal insulation is not used.

**NOTICE**

1. Some of the key elements of a residential slab application are the following:
2. Vertical edge insulation is a must (depth requirement is to go below frost line).
3. Horizontal insulation will increase the system performance and response time.
4. A minimum of 2” of slab coverage is necessary above the tubing to accommodate most slab requirements, as well as post pour conditions (frame walls, cut joints, etc.).
5. Commercial slabs follow the same guidelines with the exception of horizontal insulation. Most commercial slabs will use horizontal insulation around the edge of the slab and not under the entire slab. This is due in part to structural loading conditions and cost. Be sure to consult with the structural engineer before deciding on horizontal insulation.
6. Any post pour penetrations must be monitored closely, especially in the case of a saw cut where water is present during the cutting operation.
Type of Insulation

Extruded polystyrene insulation board is recommended mainly because the insulation board will be in direct contact with the soil. Extruded polystyrene insulation will not degrade over time due to excess moisture or soil acidity. “Beaded” insulation boards should not be used because they are not strong enough and will break down over time. This, in turn, will cause structural instability.

In most applications, 1” insulation board is recommended. A thicker board may be used if the slab is to be installed in a cold, aggressive climate. Always check with an architect or structural engineer to ensure the appropriate insulation is used.

Foil-faced insulation is not required or recommended when insulating a radiant slab. Foil-faced insulation is used when an air gap is able to be maintained. In the case of a slab application the tubing is completely encapsulated in the concrete, eliminating any air gap.

Watts Radiant does not recommend Bubble-type insulation under a slab application until more research has been done and performance has been verified. Care should be taken with all insulation types to confirm the actual R-value. Many blanket or tarp style insulations have R-values in the range of 1-1.5.

Special Construction Considerations

Slab applications are generally the easiest to install. However, it is important to remember what type of construction steps remain after the concrete slab has been poured. In most projects, the concrete is the first phase of the project. Interior walls and other support structures still have to be installed, most being mounted or secured directly to the slab. With this in mind, it is important to take some preliminary steps to help protect the tubing during construction.

Control Joints

Concrete slabs will expand and contract due to thermal changes. To prevent damage to the slab, expansion joints are used to control this movement. In some cases cut joints are used to control where cracking is to occur. Make sure the tubing is protected according to the requirements of the control joint.

Spacing

Residential slabs will use 6”, 9”, or 12” tube spacing with some perimeter banding. Spacing wider than 12” may produce unacceptable floor temperature variations (striping).

Commercial slabs may use anywhere from 6”-24” spacing depending on the use of the area.

Fasteners

Tubing can be attached to either the rewire, rebar or below slab insulation. Each of the following can be used, depending on installation requirements.
1. **CableTies**—nylon cable tie used to secure all sizes of tubing to either rewire or rebar 12”-18” on center.

2. **ScrewClips**—used to secure 3/8” or 1/2” tubing to foamboard insulation 18”-24” on center.

3. **Foamboard Staples**—used to secure 3/8” or 1/2” tubing to either foamboard or tarp insulation 18”-24” on center.

4. **RailWays**—used to secure 3/8”, 1/2”, or 5/8” tubing to various substrates. RailWays must be secured every 4 ft on center prior to the tubing being installed.

**Perimeter Banding**

Banding refers to any area where the tubing is installed with a tighter on center spacing. Usually seen along exterior walls with higher than normal heat loss.

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**Slab Profile and General Details**

In slab-on-grade applications, it is important to maintain at least 2-3” of concrete covering above the tubing. More coverage may be necessary depending on the structural requirements of the slab.

**Install Steps**

Manifold locations, final concrete thickness and zoning details are just a few items that can affect how a concrete application is installed. The following guidelines cover the most common installation conditions. If a given situation is not covered here or if unexpected circumstances arise, please contact Watts Radiant or a Watts Radiant Representative.

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**NOTICE**

1. Fastener options should be chosen based on slab construction details.
2. When deciding on a manifold location, make sure the circuit lengths used can reach the farthest point and back via right angles. Verify tubing lengths before moving a manifold location from the initial design location.
1. **Pre-Pour Conditions**
   Verify all subgrade conditions are properly prepared, all insulation is installed according to design conditions and rewire or rebar is in place. With orange spray paint, locate all interior walls and other obstacles that may need to be avoided, such as toilet areas, sewer drains, and any structural supports that may penetrate the slab.

2. **Install Manifolds**
   Locate where the manifolds are to be installed. Drive two pieces of rebar vertically into the ground and secure the manifolds with the use of cable ties or electrical tape. Keep the manifolds high enough to allow for the thickness of the concrete, the interior wall base plate and other structural items that may need to be installed after the pour. The temporary rebar supports may be removed after the slab is poured and ready for framing.

3. **Determine Zone Boundaries**
   Before tubing is installed, visually inspect the area to determine the zone boundaries. This helps determine where the first circuit is to be placed, while identifying any obstacles that may be in the way.

4. **Confirm Tubing Requirements**
   Measure the distance from the manifolds to the farthest point in the zone via right angles. Make sure the minimum circuit length is at least twice this distance. If not, the tubing will not be long enough to reach the farthest point of the zone and return.

5. **Install Tubing**
   Pull one end of the tubing off the unwinder and attach it to the first barb of one of the manifolds. Install using a single serpentine pattern, keeping the tubing 6"-8" from the edge of the slab.

   Transition sleeves should be used to protect the tubing from concrete trowels and other construction actions as it transitions from the snow melt area to the manifold location.

   If installing circuits that are shorter than the boxed coil, pay attention to the footage marking on the tubing and cut at the correct length.

   **NOTICE**
   Be careful not to step on RadiantPEX-AL as placing a person’s weight on the tubing may cause it to kink.

6. **Secure the Tubing**
   Make sure all bends and corners are securely fastened to prevent the RadiantPEX+ / RadiantPERT from curling, creating an unwanted high point in the circuit. This is generally not a concern with RadiantPEX-AL.

   Leave 2-5 ft. slack on each circuit in case the manifold position needs to be adjusted from its temporary location.

   If cable ties are used, make sure all “tails” of the cable ties are either cut off or turned downward to prevent any unwanted surface protrusions.
CAUTION: Metal wire ties may increase the risk of damage to the tubing and are not an approved Watts Radiant fastener type.

Try to keep all circuits the same length. If the last circuit is too long, try not to cut it. Shorter circuits have a lower pressure drop and will tend to cause an imbalance in the fluid flow. Some tubing may be removed from the last circuit, or any previous circuit, as long as the remaining length is within 10% of the existing circuits.

7. Inspection
After all the circuits are installed, take a few minutes to walk each circuit and visually inspect the tubing for possible damage caused during installation. If damage is found, repair it using an approved Watts Radiant repair kit. Wrap the repair with electrical tape (do not use duct tape) to protect the connection from the concrete.

8. Pressure Test
Pressure test the system with 50-100 psi water or air for 24 hours. Do not use water if exterior temperatures are near or below freezing 32°F (0°C) conditions.

9. The Concrete Pour
To help detect possible damage caused during the concrete pour, keep the system under pressure. If damage is done, locate the area in question and repair.

Some minor pressure changes will occur due to the increased internal temperatures of the concrete as it begins the curing process. Fluctuations in air temperature may also cause a slight change in the test pressure. In most cases, a 10-15 lb drop in pressure over a twenty four hour period is not uncommon.

NOTICE
1. When pressure testing a system, it is normal for the pressure to vary slightly throughout the day as air temperatures vary. For slab based systems, pressure ratings may change due to air temperature as well as thermal changes taking place within the slab.
2. Generally, a 15 psi change is not an indicator of problems. If the pressure continues to fall, then a leak may be present. Check manifold and test kit connections first then proceed to the tubing runs.

Thin-Slab Application
Most thin-slab applications are installed during the initial construction of a building, due to the increased structural requirements to carry the added weight.

Lightweight concrete products will increase the floor height by 1-1/2” and the floor load anywhere between 12 to 18 lbs/sq.ft. This increase in load usually means a modification to the joist system and/or other support modifications. It is important to verify a floor’s ability to withstand these loads prior to installing lightweight concrete product.
SECTION 15102 - WELDING

1. GENERAL

A. All welding accomplished by the Contractor shall comply with provision of the latest revision of applicable codes, whether ASME Boiler and Pressure Vessel Code for pressure piping or such State and Local requirements as may supersede these codes.

B. Welds shall be of sound metal thoroughly fused to the base metal at all points, free from cracks and reasonably free from oxidation blow holes and non-metallic inclusions. No fins or weld metal shall project within the pipe and should they occur they shall be removed. All pipe beveling shall be done by machine. The surface of all parts to be welded shall be thoroughly cleaned free from paints, oil, rust or scale at the time of welding, except that a light coat of oil may be used to preserve the beveled surfaces from rust.

C. Pipe and fittings shall be carefully aligned with adjacent parts and this alignment must be preserved in a rigid manner during the process of welding.

D. Each Contractor shall be responsible for quality of welding done by his organization and shall repair or replace any work not done in accordance with specifications. If required by the Architect/Engineer, the Contractor shall cut out at least three (3) welds during the job for X-raying and testing. These welds shall be selected at random by the Resident Inspector and shall be tested as a part of the Contractor's Contract. Certifications of these tests and X-rays shall be submitted, in triplicate to the Engineer. In case a faulty weld is discovered, the Contractor shall be required to furnish additional tests.

2. WELDING QUALIFICATIONS

A. It is required that all welding of piping covered by this specification, regardless of conditions of service, be installed as follows:

(1) Pipe welding shall comply with the provisions of the latest revision of the applicable codes, whether ASME Boiler and Pressure Vessel Code, ASA Code for Pressure Piping, or such state or local requirements as may supercede codes mentioned above.

(2) Before any pipe welding is performed, submit to the Owner or his authorized representative, a copy of the welding procedure specifications, together with proof of its qualification as outlined and required by the most recent issue of the code having jurisdiction.

(3) Before any welder shall perform any pipe welding, submit to the Owner or his authorized agent the operator's qualification record in conformance with the provisions of the code having jurisdiction, showing that the operator was tested under the proven procedure specifications submitted.
(4) Standard Procedure Specifications and Welders qualified by the National Certified Pipe Welding Bureau shall be considered as conforming to the requirements of these specifications.

(5) “R” Stamp: Any welder performing modifications, repairs, etc. to boilers, pressure vessels, or other pressure retaining items shall have a current R stamp issued by the National Board of Boiler and Pressure Vessel Inspectors.

(6) “PP” Stamp: Any welder working with steam systems exceeding 15 PSIG shall have a current PP stamp issued by ASME. This shall apply up to the first stop valve for single boiler installations and up to the second stop valve for multiple boiler installations.

B. MATERIALS

(1) Welding fittings shall conform to ASA B16.9; of the same materials, thickness, etc., as the pipe being jointed; see ASA B36.10.

END OF SECTION 15102
SECTION 15110 - VALVES AND COCKS

1. GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, General Conditions-Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified herein.

B. The Contractor shall provide all valves required to control, maintain and direct flow of all fluid systems indicated or specified. This shall include, but may not be limited to all valves of all types including balancing cocks, air cocks, lubricated plug cocks, packed plug cocks, special valves for special systems, etc., for all Mechanical Systems.

C. All valves shall be designed and rated for the service to which they are applied.

D. The following type valves shall not be acceptable: Zinc, plastic, fiber or non-metallic.

E. Ball valves with temperature and pressure ports are not an acceptable alternative to the balancing valves specified herein. Valves that do not comply with these specifications shall be removed and replaced by the Contractor with no increase in contract price.

F. Each type of valve shall be of one manufacturer, i.e., gate valves, one manufacturer, globe valves, one manufacturer, silent check valves, one manufacturer, etc. The following valve manufacturers shall be acceptable: Lunkenheimer, Tour & Anderssen, Powell, Nibco, Crane, Jenkins, T & S Brass, Walworth, Milwaukee, DeZurik, Consolidated Valve Industries, Inc., Victaulic, Bell & Gossett, Flow Design, Watts.

G. All valves shall comply with current Federal, State and Local Codes.

H. All valves shall be new and of first quality.

I. All valves shall be full line size. Valves and hydronic specialties shall not be reduced to coil or equipment connection size. Size reductions shall be made at the connection to the equipment.

J. Angle stops for plumbing fixtures shall be quarter turn ball type.

K. All valves for use in potable water systems shall comply with federal lead free requirements that the lead content of wetted surfaces cannot exceed 0.25% by weight.

2. LOCATION OF MAINTENANCE VALVES

Maintenance valves and unions, installed so as to isolate equipment from the system shall be installed at the following locations:

A. At each plumbing fixture.
B. At each air handling unit, and make–up air unit.

C. At each unit heater.

D. At each heating or cooling coil.

E. At all other locations indicated on the drawings.

3. WORKMANSHIP AND DESIGN

A. Handwheels for valves shall be of a suitable diameter to allow tight closure by hand with the application of reasonable force without additional leverage and without damage to stem, seat and disc. Seating surfaces shall be machined and finished to insure tightness against leakage for service specified and shall seat freely. All screwed valves shall be so designed that when the screwed connection is properly made, no interference with, nor damage to the working parts of the valve shall occur. The same shall be true for sweat valves when solder or brazing is applied.

4. TYPES AND APPLICATION

A. GATE VALVES

Gate Valves shall be of the wedge disc type, permit straight line flow, complete shut-off and designed so that when the valve is wide open, it can be packed under pressure. Valves 1-1/2 inches and smaller shall be bronze, with ends to suit piping and non-rising stem. The valve shall have a deep stuffing box for long contact with the stem, packing gland and filled with high quality packing. Valves 2 inches thru 4 inches shall be iron body bronze mounted with flanged ends and non-rising stem. Boiler stop valves and valves larger than 4 inches shall be iron body bronze mounted flanged ends with outside screw and yoke with rising stem. Working pressure for bronze valves shall be 150 pounds and iron valves 125 pounds when installed in piping with system pressures up to 100 pounds per square inch and 250 pounds for 100 pounds per square inch and over. 2” and under NIBCO T133, greater than 2” NIBCO F619. All gate valves 2” and smaller for use in potable water systems shall meet federal requirement to be lead free containing less than 0.25% lead by weight of wetted area. NIBCO F768B. All gate valves 2” and smaller for use in potable water systems shall meet federal requirement to be lead free containing less than 0.25% lead by weight of wetted area. NIBCO F768B.

B. GLOBE VALVES

Globe Valves shall permit control of flow rate from full flow to complete shut-off and designed that when the valve is wide open it can be repacked under pressure, and have a deep stuffing box with gland and filled with high quality packing. Valves 1-1/2 inches and smaller shall be bronze with ends to suit piping union bonnet, and with stainless steel plug type disc and seat of not less than 500 Brinell hardness. Valves 2 inches and larger shall be iron body bronze mounted with flanged ends, yoke bonnet, and disc guide. Working pressure for bronze valves shall be 150 pounds and iron valves 125 pounds when installed in piping with system pressures up to 100
pounds per square inch and 250 pounds for 100 pounds per square inch and over. 1-1/2" and under NIBCO T256AP, greater than 1-1/2" NIBCO F768B.

C. CHECK VALVES

Check Valves shall be horizontal swing type with two piece hinges, disc construction seats to be bronze and bronze discs or with composition face depending on service and provide silent operation. Valves 1-1/2 inches and smaller shall be bronze with ends to suit piping, have full area "Y" pattern body and integral seats. Valves 2 inches and larger shall be iron body brass mounted and with flanged ends. Working pressure for bronze valves shall be 150 psi and iron valves 125 psi when installed in piping with system pressures up to 100 psi and 250 psi for 100 psi and over. 3" and under NIBCO T433Y, greater than 3" NIBCO F918B (for less than 100 psi systems) greater than 3" NIBCO F968B (for 100 psi or greater systems).

D. BALL VALVES (NON-POTABLE)

Ball Valves shall have removable lever handle with vinyl grip, adjustable stem gland screw, reinforced Teflon stuffing box ring, blow out proof stem, bronze body, reinforced Teflon seats, chrome plated steel ball as manufactured by Consolidated Valve Industries, Inc., Lunkenheimer, Apollo, Jenkins, Nibco or equivalent. Provide a stem extension so that the base of the handle is 1/4" above the insulation. NIBCO T5800-70.

E. BALL VALVES (POTABLE WATER)

All valves for use in potable water systems 2" and smaller contain less than 0.25% lead by weight and comply with federal lead free potable water requirements. Ball valves shall have a removable lever handle with vinyl grip, adjustable stem gland screw, reinforced Teflon stuffing box ring, blowout proof stem, stainless steel or bronze body, reinforced Teflon seats, stainless steel or chrome plate steel ball as manufactured by Appollo, Aslo, Nibco, Milwaukee, or equivalent. Provide a stem extension so that they bas of the handle is ¼” above the insulation. NIBCO S-585-66-LF.

F. BUTTERFLY VALVES

Butterfly valves shall be line sized cast iron body, lug style, 200 PSI rating (bubble tight) EPT or Viton seat, cartridge type; high strength stem. Disc to have ground and polished seating surface. Operator shall be locking lever style. Quality equivalent to Crane Monarch series. 3" and under NIBCO LD3222-3, greater than 3" NIBCO LD322-5.

G. BALANCING VALVES

Bell & Gossett, Model CB circuit setter balancing valve or approved equivalent. Calibrated balancing valve shall have flanged connections suitable for 125# working pressure at 250°F. 4" and up shall be rated at 175# at 250°F working pressure. Provide with brass readout valves fitted with an integral EPT insert and check valve. Each balance valve shall have a calibrated
nameplate to assure specific valve settings and be constructed with internal seals to prevent leakage.

H. AIR COCKS

Straight nose; Lunkenheimer Fig. 476; bronze; tee handle; bent nose; Lunkenheimer Fig. 478, 125#; bronze; tee handle.

I. GAUGE COCKS

Straight, Lunkenheimer, Fig. 1178; 125#; bronze; tee handle. FIP.

J. LUBRICATED PLUG COCKS

2" and under; Homestead Fig. 601; 150#; semi-steel; screwed; 2-1/2" and over; Homestead Fig. 602; ±50#; semi-steel; flanged.

K. PACKED PLUG COCKS

2" and under; DeZurik Fig. 425-S; 175#; semi-steel; screwed. 2-1/2" and over; DeZurik Fig. 425-F; 175#; semi-steel; flanged.

END OF SECTION 15110
SECTION 15120 - ACCESS TO VALVES, EQUIPMENT, FILTERS, ETC.

1. GENERAL

   A. The Contractor's attention is directed to the General and Special Conditions, General Requirements-Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified herein.

   B. All mechanical equipment shall be installed in a manner which allows ready access to all components requiring service, adjustments, shutoff, etc.

   C. Filters shall be accessible, removable and replaceable without disconnecting mounting brackets, piping, wiring, etc.

   D. All oil cups, grease cups, grease fittings, etc. shall be accessible without disassembly of equipment, piping, ductwork, etc. (Extended oilers or grease fittings may be required).

   E. Provide access doors or panels for all equipment, valves, dampers, filters, fire dampers, etc. in concealed spaces not otherwise provided with suitable access. (Lay-in ceilings shall be considered acceptable access; splined or drywall ceilings shall not).

   F. All valves, unions, strainers, cleanouts, volume dampers, and test points shall be accessible.

   G. Access panels in lay-in ceilings shall be labeled with a lamacoid plate to indicate location of equipment, filters, valves, etc.

   H. Access panels in fire rated walls shall bear the same rating as the wall.

   I. Each fire damper shall be provided access through the duct to allow reset of the damper. This may be either a gasketed sheet metal panel over a suitable opening or a factory-built access panel. The panel shall be at least one and one-half (1½) inch larger than the opening all around and shall be held in place with sheet metal screws sufficiently to ensure that it is air tight. Manually check the size and location of each of these openings to ensure that the fire damper may be manually reset by use of hand only.

2. ACCESS DOORS

   Refer to Sheet Metal and Flexible Duct section of the specifications.

END OF SECTION 15120
SECTION 15125 - THERMOMETERS & OTHERS, MONITORING INSTRUMENTS

1. GENERAL

   A. The Contractor shall include all thermometers, pressure gauges and/or compound gauges at the locations indicated.

2. THERMOMETERS AND PRESSURE GAUGES

   A. All thermometers and gauges shall be readable from a standing position on the floor.

   B. Thermometers shall be linear, alcohol filled, graduated in 1°F or less and shall have adequate range for service intended.

   C. Pressure gauges shall be Bourdon Type, circular, 3" face, black letters on white face graduated in 2 PSI or less and shall have adequate range and shall be manufactured for service intended. Provide with pig tail connectors and gauge cocks.

   D. Pressure gauges and thermometers subject to vibration shall be mounted remotely away from vibrating pipe surface, etc., with flexible tubing.

   E. Mount thermometers in approved wells and install with thermal grease. Do not make direct contact of base with fluid in pipe.

   F. Gauges and thermometers shall be Marsh, Marshalltown, Weksler or equivalent.

3. Provide, when indicated on the plans, on the inlet and outlet of each terminal unit, a “Pete’s Plug” or equivalent pressure/temperature test station. Furnish two (2) matching thermometers and pressure gauges to the owner upon project completion.

END OF SECTION 15125
SECTION 15200 – MECHANICAL/ELECTRICAL VIBRATION CONTROLS AND SEISMIC RESTRAINTS

1. GENERAL

   A. RELATED DOCUMENTS

      (1) Drawings and general provisions of the Contract, including General and Supplementary Conditions, General Mechanical Provisions and Division 1 Specifications Sections, apply to this section.

   B. MANUFACTURERS

      (1) Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include:

         Mason Industries
         Vibration Eliminator Co., Inc.
         Vibration Isolation Co., Inc.
         Kinetics Noise Control
         Vibration Management Corporation - Vimco

         All Seismic restraint devices; isolators, calculations and seismic design shall be provided by a single vibration isolator manufacturer as listed above.

   C. SUMMARY

      (1) This Section includes vibration isolators, vibration isolation bases, and seismic restraints and snubbers for mechanical and electrical equipment, duct and piping systems.

         Drawings and calculation
         Certification of seismic restraint designs
         Installation supervision

   D. PROJECT CONDITIONS

      (1) Building Classification Category is IV (2013 KBC – Table 1604.5).

      (2) Seismic Design Category: C


      (4) Component Importance Factor is 1.5 for all Mechanical and Electrical Systems

         a. The interrelationship of components and their effect on each other shall be considered so that the failure of any essential or non-essential architectural, mechanical or electrical component shall not cause the failure of another essential architectural, mechanical or electrical component.
(5) Duct restraints are not required if conditions of ASCE 7-05; Chapter 13 paragraph 13.6.7 are met.

(6) Piping restraints are not required if conditions of ASCE 7-05; Chapter 13; paragraph 13.6.8 are met.

(7) Fire Protection Sprinkler Systems: Refer to ASCE 7-05; Chapter 13, paragraph 13.6.8.2 and 13.6.8.3.

E. APPLICABLE CODES AND STANDARDS

(1) The Kentucky Building Code; 2013; Chapter 16, 17

(2) ASCE 7-05, Chapter 13.

F. SUBMITTALS

(1) Product Data: Indicate types, styles, materials, and finishes for each type of isolator and seismic restraint specified. Include load deflection curves.

(2) Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to the structure and to the supported equipment. Include auxiliary motor slides and rails, and base weights.

G. SEISMIC RESTRAINT SUBMITTALS

(1) Shop Drawings: Show designs and calculations, prepared and stamped by a licensed professional engineer, for the following:

a. Design Calculations: Calculations for design and selection of seismic restraints for equipment (including fire pump and related equipment), duct and piping systems (including risers), stamped by a licensed professional engineer.

b. Analysis must include calculated dead loads, static seismic loads and capacity of materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embedment and/or welded length. All seismic restraint devices shall be designed to accept, without failure, the forces detailed in listed building codes acting through the equipment center of gravity. Overturning moments may exceed forces at ground level.

c. Seismic Restraint Details: Detail fabrication and attachment of restraints and Snubbers.

d. Concrete Pad Details: Show required concrete pad size and location for equipment. Show locations of required pad anchors and stud wedge anchors.

e. Where wall, floors, slabs, or supplementary steel work are used for seismic restraint locations, details of acceptable attachment methods for ducts, conduit and pipe must be included and approved before the condition is accepted for installation. Restraint
manufacturers’ submittals must include spacing, static loads and seismic loads at all attachment and support points.

H. SEISMIC RESTRAINT QUALITY ASSURANCE

(1) Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in the jurisdiction where the Project is located and who has a minimum of 5 years experience in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of vibration isolation bases and seismic restraints that are similar to those indicated for this Project in material, design, and extent.

2. PRODUCTS

A. VIBRATION ISOLATORS

(1) Rubber Isolator Mounts: Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements, with encapsulated top-and baseplates. Factory drilled and tapped top plate for bolted equipment mounting. Factory-drilled baseplate for bolted connection to structure. Color-code to indicate capacity range.

(2) Restraint Spring Isolators: Vertically restrained, freestanding, laterally stable, steel open-spring-type isolators.

(3) Housing: Welded steel or ductile iron. Factory-drilled baseplate for bolting to structure and bonded to a 1/4 -inch-(6mm) thick, rubber isolator pad attached to the baseplate underside. Provide adjustable equipment mounting and leveling bolt.

(4) Outside Spring Diameter: Not less than 80 percent of the compressed height of spring at rated load.

(5) Minimum Additional Travel: 50 percent of the required deflection at rated load.

(6) Lateral Stiffness: More than 0.8 times the rated vertical stiffness.

(7) Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

(8) Finishes: Baked enamel for metal components on isolators for interior use. Hot-dip galvanized for metal components on isolators for exterior use.

(9) Vertical Limit Stops: Where required or shown, provide resilient vertical limit stops to prevent spring extension due to wind loads or when weight is removed.

(10) Rubber Hangers: Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements bonded to formed-steel housings with threaded connections for hanger rods. Color-code to indicate capacity range.

(11) Spring Hangers: Combination spring and elastomeric hanger with coil spring and elastomeric insert in compression.
(12) Frame: Formed steel, fabricated for connection to threaded rods and to allow for 30 degrees of angular hanger rod misalignment without binding or reducing isolation efficiency.

(13) Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

(14) Minimum Additional Travel: 50 percent of the required deflection at rated load.

(15) Elastomeric Element: Molded, oil-resistant rubber or neoprene.

(16) All-directional acoustical pipe anchor shall consist of two sizes of steel tubing separated by a minimum ½” thick 60 durometer neoprene. Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction. Allowable loads on the isolation material should not exceed 500 psi and the design shall be balanced for equal resistance in any direction.

(17) Seismic solid braces shall consist of steel angles or channels to resist seismic loads with minimum safety factor of 2 and arranged to provide all directional restraint. Seismic solid brace end connection shall be steel assemblies that swivel to the final installation angle and utilize two through bolts to provide proper attachment. Seismic solid brace assembly shall have anchorage pre-approval “R” number OSHPD in the state of California verifying the maximum certified load ratings.

(18) Housekeeping pad anchors shall consist of a ductile iron casting that is tapered and hexagonal, smaller at its base than at its top. The upper portion shall have holes for rebar to pass through. The anchor should be continuously threaded from top to bottom for the attachment of soleplates. Housekeeping anchors shall be attached to the structural slab using stud wedge anchors.

(19) Stud wedge anchors shall be manufactured from full diameter wire, not from undersized wire that was “rolled up” to create the thread. The stud anchor shall also have a safety shoulder, which fully support the wedge ring under load. The stud anchors shall have an evaluation report number from the I.C.B.O. Evaluation Service, Inc. verifying its allowable loads.

(20) Female wedge anchors are preferred in floor locations so isolators or equipment can be slid into place after the anchors are installed. Anchors shall be manufactured from full diameter wire, and shall have a safety shoulder to fully support the wedge ring under load. Female wedge anchors shall have evaluation report number from the I.C.B.O. Evaluation Service, Inc. verifying to its allowable loads.

B. VIBRATION ISOLATION BASES

(1) Fabricated Steel Bases: Structural-steel bases and rails designed and fabricated by the isolation equipment manufacturer. Include equipment static loadings, power transmission, component misalignment, and cantilever loadings.

(2) Fabricate bases to shapes required, with welded structural-steel shapes, plates and conforming to ASTM A 36 (ASTM A 36M). Include support brackets to anchor base to isolators units. Include prelocated equipment anchor bolts and auxiliary motor slide bases or rails.
(3) Design and fabricate bases to result in the lowest possible mounting height with not less than an inch (25-mm) clearance above the floor.

(4) Concrete-Filled Inertia Bases: Weld reinforcing bars to the structural frame. Pour concrete into base with relocated equipment anchor bolts.

(5) Weld steel angles on frame for outrigger isolation mountings, and provide for anchor bolts and equipment support.

(6) Configure inertia bases to accommodate equipment supported.

(7) Pump Bases: Size to support pump and piping elbows.

(8) Factory Finish: Manufacturer’s standard corrosive-resistant finish.

C. SEISMIC CONTROLS

(1) Thrust Restraints: Combination spring and elastomeric restraints with coil spring and elastomeric insert in compression. Factory set for thrust.

(2) Frame: Formed steel, fabricated for connection to threaded rods and to allow for 30 degrees of angular hanger rod misalignment without binding or reducing isolation efficiency.

(3) Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

(4) Minimum Additional Travel: 50 percent of the required deflections at rated load.

(5) Elastomeric Element: Molded, oil-resistant rubber or neoprene.

(6) Finishes: Baked enamel for metal components. Color-code to indicate capacity range.

(7) Seismic cable restraints shall consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two and arranged to provide all-directional restraint. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize two clamping bolts to provide proper cable engagement. Cables must not be allowed to bend across sharp edges.

(8) Manufactured Seismic Snubbers: All-directional, double-acting snubbers

(9) Construction: Interlocking steel members restrained by ¾-inch-(19-mm-) thick, replaceable, shock-absorbing neoprene insert. Maintain 1/8-inch (3mm) clearance in all directions between rigid and resilient surfaces.

(10) Fabricated Seismic Snubbers: Welded structural-steel designed and fabricated to restrain equipment or vibration isolation bases from excessive movement during a seismic event. Design to resist gravity forces identified by authorities having jurisdiction.

(11) Construction: Welded steel shapes conforming to ASTM A 36 (ASTM A 36M)
(12) Resilient Components: ¼ inch-(19-mm-) thick, replaceable, shock-absorbing neoprene insert.

(13) Flexible Stainless Steel Hose: Hoses shall be installed on equipment side of shut-off valves horizontally and parallel to the equipment shafts wherever possible.
   b. Connection: Less than 3”: Male nipples.

3. EXECUTION

A. INSTALLATION

(1) Install and anchor vibration-, sound-, and seismic-control products according to manufacturer’s written instructions and authorities having jurisdiction.

(2) Anchor interior mounts, isolators, hangers, and snubbers to vibration isolation bases. Bolt isolator baseplates to structural floors as required by authorities having jurisdiction.

(3) Filled concrete inertia bases, after installing base frame, with 3000-psig (20.7-Mpa) concrete, and trowel to a smooth, hard finish. Cast-in-place concrete is specified in Division 3.

(4) Isolate duct as follows:
   a. Provide spring and neoprene hanger or floor spring mount on all duct discharge runs for a distance of 50’ from the connected equipment. Spring deflection shall be a minimum of 0.75”.
   b. Provide precompressed spring and neoprene hanger or floor spring mount on all duct runs having air velocity of 1000 fpm or more. Spring deflection shall be a minimum of 0.75”.

(5) Isolated piping as follows:
   a. Horizontal pipe isolation: The first three pipe hangers in the main lines near the mechanical equipment shall be precompressed spring and neoprene type. Floor supported piping shall rest on spring type isolators. If piping is connected to equipment located in basements and hangs from ceilings under occupied spaces the first three hangers shall have 0.75” deflection for pipe sizes up to and including 3”, 1 ½” deflection for pipe sizes up to and including 6”, and 2 ½” deflection thereafter.
   b. Riser isolation: Risers shall be suspended from spring and neoprene hangers or supported by floor spring isolators, all-directional acoustic pipe anchor, and pipe guide. Steel springs shall be a minimum of 0.75” except in those expansion locations where additional deflection is required to limit load changes to +25% of the initial load. Submittals must include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on the building structure, spring deflection changes and seismic loads. Submittal data shall include certification that the riser system has been examined for excessive stresses and that none will exist in the proposed design.

B. SEISMIC CONTROL
(1) All mechanical systems are to be seismically restrained. Equipment buried underground is excluded but entry of services through the foundation wall is included. Equipment referred to below is typical (equipment not listed is still included in this specification).

(2) Ductwork, where seismically restrained, must be reinforced. Reinforcement shall consist of all additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to the support hanger rods. Ductwork is to be attached to both upper angle and lower trapeze.

(3) Vibration Isolation Bases: Mount equipment on structural-steel bases or concrete inertia bases.

(4) Snubbers: Install the required number of seismic snubbers on each spring-mounted piece of equipment. Locate snubber as close as possible to the vibration isolators and bolt to supporting structure.

(5) Manufacturer shall provide installation instructions, drawings and trained field supervision to insure proper installation and performance. Visit the project site before installation is begun and instruct installers in correct installation procedures for vibration isolation, seismic restraints and concrete pads. Observe installation of other work related to vibration isolation and seismic work, including concrete pad installations; and, after completion of other related work (but before equipment startup), shall furnish written report to Contractor listing observed inadequacies for proper operation and performance of vibration isolation work. Report shall cover the following:

a. Equipment installations (performed as work of other sections) on vibration isolators and Seismic restraints.

b. Piping connections including flexible connections.

c. Ductwork connections including provisions for flexible connections.

d. Passage of piping and ductwork which is to be isolated through walls and floors.

e. Installation of isolators and seismic restraints on duct and piping systems.

(6) Do not start-up equipment until inadequacies have been corrected in manner acceptable to Vibration Isolator and Seismic Controls Manufacturer.

(7) Spacing for restraints shall be as follows, except where lesser spacing is required to limit anchorage loads:

a. Ductwork and electrical services (conduit, bus ducts, cable trays, and ladder trays) transverse restraints shall occur at 30’ intervals (or at both ends of the duct run if less than specified interval) and longitudinal restraints shall occur at 60’ intervals (with at least one restraint per duct run). Transverse restraints shall be installed at each duct/electrical services turn and at each end of a duct/electrical run.
b. Walls including gypsum board non-bearing partitions, which have ducts running through them may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.

END OF SECTION 15200
SECTION 15400 - PLUMBING SPECIALTIES

1. GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, General Conditions-Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work specified in this section.

B. The Contractor shall provide all equipment and specialties complete with trim required and connect in a manner conforming to the Kentucky Building Code.

C. The Contractor shall obtain exact centerline rough-in dimensions between partitions, walls, etc. as required for lay-out of his rough-in work. All work shall be roughed-in so that all exposed piping will be straight and true without bends or offsets.

D. Prior to final inspection, test by operation at least twice, all equipment.

E. Prior to final inspection, remove all stick-on labels, dirt, grease, other removable stampings, lettering, etc. from equipment and specialties and thoroughly clean same.

F. All equipment and specialties shall be installed as recommended by the manufacturer in a neat and workmanlike manner. Unacceptable workmanship shall be removed and replaced at the installing Contractor's cost.

2. DRAINAGE SPECIALTIES

A. GENERAL

(1) Provide all drainage specialties indicated, specified and/or required to provide complete and acceptable removal of all storm, sanitary, waste, laboratory waste, etc. from the building and into approved receptors.

(2) Drainage specialties shall be on non-electrolytic conduction to the material to which they are connected.

(3) Drainage specialties shall be installed in a manner so as to insure no leakage of toxic or odorous gases or liquids and shall have traps and/or backflow preventers where required. Nor shall they allow backflow into other or existing systems.

B. CLEANOUTS - INTERIOR (CO)

(1) In addition to cleanouts indicated, provide cleanouts in soil and waste piping and storm drainage at the following minimum locations:

   a. At base of each stack.
b. At fifty (50) foot maximum intervals in horizontal lines.
c. At each change of direction of a horizontal line.
d. As required by current KBC.
e. As required to permit rodding of entire system. (If in doubt, contact Engineers.)

(2) Water closets, slop sinks and other fixtures with fixed traps shall not be accepted as cleanouts.

(3) Cleanouts and/or test tees concealed in inaccessible pipe spaces, walls and other locations shall have an eight (8) inch by eight (8) inch (minimum) access panel or cover plates shall be set flush with finished floors and walls and shall be key or screw driver operable.

(4) Access panels for cleanouts shall be of the Zurn, 1460 series or equivalent by Josam or Watts. Where they are not to receive paint, they shall be polished bronze unless otherwise indicated where they are to receive paint or other finishes. They may, at the Contractor's option, be Perma-Coated steel, prepared to receive finish.

(5) Cleanouts and access panels shall be sized so as to permit the entry of a full sized rodding head capable of one hundred percent circumferential coverage of the line served.

(6) Provide a non-hardening mixture of graphite and grease on threads of all screwed cleanouts during installation.

(7) Do not install cleanouts against walls, partitions, etc. where rodding will be difficult or impossible. Extend past the obstruction.

(8) In finished walls, floors, etc., insure that cleanouts are installed flush with finished surfaces and, where required, grout or otherwise finish in a neat and workmanlike manner.

(9) Cleanouts shall be as manufactured by Zurn, Josam, Jay R. Smith, Watts, MIFAB, Ancon or equivalent, similar to the following:

a. Zurn, Z-1440 cleanouts or Z-1445 cleanout tee at base of exposed stack and at change in direction of exposed lines.

b. Zurn, Z-1440 cleanout or Z-1445-1 cleanout tee where stacks are concealed in finished walls

c. Zurn, ZN-1400-T cleanout with square scoriated top in finished concrete and masonry tile floors.

d. Zurn, ZN-1400-Tx cleanout with square recessed top for tile in vinyl and linoleum finished floors.

e. Zurn, ZN-1400-Z cleanout with round recessed top for terrazzo floors.
f. Zurn, Z-1400-HD cleanout with tractor cover for exterior locations. Provide concrete supporting pad crowned to shed water. Refer to drawings for pad size.

g. Mueller, No. D-731 or D-714, Nibco, Flage or equivalent for cleanouts in copper waste with cover plates and/or access panels listed for other cleanouts.

h. Threaded hex head type cleanouts of same materials as pipe for piping 2" and smaller.

i. Zurn, cleanout with round top with adjustable retainer for carpet area. Install flush with carpet.

C. FLOOR DRAINS

(1) Provide floor drains at locations indicated and/or as required by Kentucky Building Code. Install in a neat and workmanlike manner. Coordinate locations with appropriate persons or party to insure floor pitch to drain where required.

(2) Install floor drains in strict accordance with manufacturer's recommendations and the KBC unless otherwise indicated.

(3) Each floor drain located on floors above the lowest floor shall be provided complete with a three (3) foot by three (3) foot, four (4) pound sheet lead flashing and clamping collar or chlorinated polyethylene shower pan liner of 30 mil. Lead pans shall be given a heavy coat of asphaltum on bottom and sides before installation and a heavy coat on exposed surfaces (if any). After installation, provide one ply of fifteen (15) pound roofing felt beneath each pan.

(4) Insure by coordination with the appropriate persons or party that spaces served by a floor drain(s) has a water seal extending at least three (3) inches from the floor of the space served on all floors above the lowest level.

(5) The floor drains shall be Zurn, Josam, Watts, Jay R. Smith, MIFAB, Sioux Chief or equivalent, similar to the following:

a. FD-1 - Zurn, Z-415 with 6" X 6" top, Type "S" strainer. Provide with trap primer connection.

b. FD-2 - Zurn, ZN-610 with 12" X 12" locking grate, secondary strainer, sediment bucket, and galvanized cast iron construction with trap primer connection.

c. FD-3 – Zurn, Z415 with Type “E” strainer with 4” diameter funnel. Provide with trap primer connection.

D. TRAP PRIMERS
Provide trap primers for all floor drains and open receptacle. Acceptable Trap Primer Manufacturers included Zurn, Precision Plumbing Products and Sioux Chief. Trap Primer selection shall be as follows:

(1) Trap Primer Type-1 (TP-1)

Precisions Plumbing Products Prime-Time or equal electronic trap priming manifold, with atmospheric vacuum breaker, pre-set 24 hour clock, manual override switch, 120 volt solenoid valve with 120v/3wire connection. Provide in 12” x 12” x 4” surface mounted metal cabinet. Provide with 10 opening manifold, un-used manifold opening shall be capped. Install united as required by manufacturer.

E. CLEANOUTS (EXTERIOR) (ECO)

Provide exterior cleanouts at each location indicated and in the manner indicated. Permanently set all exterior cleanouts centered in a 30” X 30” X 6” deep concrete pad. The top of the concrete pad shall be flush with finished grade. The top of the cleanout box shall be flush with the top of the pad and shall be stamped "CO."

F. ROOF DRAINS

(1) Each drain shall be provided complete with a three (3) foot by three (3) foot, four (4) pound sheet lead flashing and clamping collar. Roof drains shall be installed in strict accordance with the drain manufacturers and roofing manufacturer’s instructions. Provide all accessories required for a complete installation.

(2) RD-1, Zurn, Z-100 15", or equivalent, diameter roof drain, dura-coated cast iron body with combination membrane flashing clamp/gravel guard and low silhouette cast iron dome. Provide with any accessories needed for installation in roof specified by Architect and as recommended by the roofing manufacturer.

(3) RD-2 (Overflow Roof Drain with external water dam) Zurn, Z-100-89 , or equivalent, 15” diameter roof drain, dura-coated cast iron body with 2” high combination membrane flashing clamp/gravel guard and low silhouette cast iron dome. Provide with any accessories for installation in roof specified by the Architect and as recommended by the roofing manufacturer.

G. HEADWALLS (HW)

Provide at the locations indicated and/or as required by Federal, State and/or local codes, rules, regulations, standards and/or requirements, headwalls of the type required or indicated. Install as prescribed by local authority or as indicated, whichever is superior.

H. VARMINT GUARDS
Provide at each live discharge and/or culvert discharge (where culvert exceeds 30 linear feet in length) and where the line has a surface opening greater than one-half (\(\frac{1}{2}\)) square feet, a three (3) inch mesh steel varmint guard made up with frame and 3/8 inch minimum steel rods welded together and affixed tightly into the end of the open pipe.

3. WATER SUPPLY SPECIALTIES

A. GENERAL

(1) Provide all water supply specialties indicated, specified and/or required for the complete installation. Install in a neat and workmanlike manner in accordance with the manufacturer's recommendations and the KBC.

(2) Where required by the KBC, install code approved vacuum breakers in each water supply specialty.

B. FREEZEPROOF WALL HYDRANTS (FPWH)

(1) Provide code approved wall hydrants at each location indicated in a neat and workmanlike manner. Affix tight to walls and insure that the feed piping is on the heated side of the building insulation blanket.

(2) Where hydrants are of handwheel type, remove handwheels and turn over to owners in an envelope labeled "Wall Hydrants" exterior upon completion of the project.

(3) Where hydrants have key operators, turn over at least two (2) keys in an envelope labeled "Wall Hydrants" to owners upon completion of the project.

(4) Where hydrants have lockable boxes, turn over at least two (2) keys in an envelope labeled "Wall Hydrants, Exterior" to owners upon completion of project.

(5) Mount all wall hydrants at least twenty (20) inches above finished exterior grade. Where this is not possible or practical, contact Engineers.

(6) Wall hydrants shall be as follows or equivalent:

   a. Zurn 1300 or equivalent, 3/4", encased, flush, non-freeze wall hydrant with key lock and combination backflow preventer/vacuum breaker.

C. HOSE BIBBS (HB)

(1) Provide code approved hose bibbs with vacuum breakers and male threaded spouts at each location indicated and as follows:

(2) Do not install hose bibbs spaces which do not have existing planned or installed floor drains even if sill cocks are indicated for these areas.
(3) Hose bibbs shall be mounted at eighteen (18) inches above finished floor served.

(4) The hose bibb shall be Zurn equivalent similar to the following:


D. BOILER DRAINS (BD)

Install 3/4 inch bronze body boiler drains, similar and equivalent to Nibco, No. 72 or 73, as indicated and at the following locations:

(1) At the low point of the plumbing system.

(2) On boiler low point.

(3) In each hot water heater and/or storage tank.

(4) At the low point of each hydronic system.

(5) On the water refrigeration machine (100 percent drainage).

(6) On each water storage tank.

(7) At each pump suction.

(8) At the low point of each isolatable section of any system carrying water.

NOTE: Install a code approved vacuum breaker where installation on to domestic water system.

E. WATER HAMMER ARRESTORS (WHA): Provide water hammer arrestors at each location indicated and/or as required to eliminate hydrostatic on the domestic water system. Provide at least one water hammer arrestor at all quick acting valve locations including:

Automatic Clothes Washers – Type “A”
Commercial Dishwashers – Type “B”
Sterilizers – Type “B”
Mop Basins (downstream of check valve) – Type “A”
Flush valve fixtures - Type “B” (Each toilet room with 1-3 flush valve fixtures shall have its own Type “B” water hammer arrestor.)
(1) Multiple Fixtures – Branch Line Less Than 20’ Long: The preferred location for a Zurn Shoktrol is at the end of the branch line between the last two fixtures when the branch lines do not exceed 20’ in length, from the start of the horizontal branch line to the last fixture supply on this line.

(2) Multiple Fixtures – Branch Line More Than 20’ Long: On branch lines over 20’ in length, use two Shoktrols whose capacities total the requirement of the branch. Locate one unit between the last and next to last fixture and the other unit approximately midway between the fixtures.

(3) Water hammer arrestors shall be Zurn, Z-1700, Shoktrol, Smith, Josam, Wade, or equivalent. Water hammer arrestors shall be stainless steel, bellows type. Field fabricated capped cylinders shall not be acceptable.

(4) Note: Provide insulation unions where arrestors are of dissimilar material from the piping served (unless piping is non-conducting, such as ABS or PVC).

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<td>ZURN, Z-1700 # 400</td>
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F. PRESSURE REDUCING VALVES (PRV)

Install at each location indicated and/or as required to reduce domestic building water service to a maximum of eighty (80) PSIG code approved pressure reducing stations with by-pass. Install in a manner indicated or as required. Provide unions and stops for removal of station. PRV shall be adjustable from thirty (30) percent above or below reduced pressure. Where this cannot be attained with single stage, provide multiphased reduction.

G. REDUCED PRESSURE BACKFLOW PREVENTERS (RPBP)

Watts #909 or equivalent reduced pressure backflow preventer. Provide with gate valves for isolation, FDA food grade strainer and air gap fitting. RPBP shall be UL listed.

H. DOUBLE CHECK VALVE ASSEMBLY

Watts #709, Watts #757, or equivalent double check valve assembly. Provide with FDA approved food grade strainer and gate valves for isolation. Assembly shall be UL listed.
I. DOMESTIC HOT WATER HEAT TRACE

(1) General

Furnish and install a U.L. listed system of electric self-regulating heating cable and components for maintaining the water temperature in the domestic hot water lines as indicated on drawings. Domestic hot water temperature maintenance system shall be a Raychem Hwat-Plus system, Thermon, Nelson or Bylin. Contractor shall provide power connection kits, splice connection kits, tee connection kits, end seal kits, glass tape, electric traced labels, cables, ground fault protection device, junction boxes and all other electrical and mechanical components required to install a complete and working system that shall maintain the domestic water temperature as listed on the drawings. Install the system per manufacturer's installation recommendations. The Contractor furnishing and installing the system shall coordinate with the Electrical Contractor to insure all electrical requirements have been identified and shall have the electrician provide power to all circuits of the heat trace system. System shall be tested by vendor by a 2500 volt Meggar test with a minimum of 20 megohms prior to insulation. The Contractor shall inform the Engineer 7 days prior to this test. Provide insulation and insulation size per manufacturer's recommendations.

(2) Cable

Heating cable shall have a polyolefin color coded outer jacket, tinned copper braid, polymer coated aluminum wrap, radiation cross-linked polyolefin coated insulating jacket, bus wires, radiation cross-linked, self-regulating conductive core.

(3) Over-site & Warrantee

The cable shall have a 10 year product defect warrantee. The complete installation shall have a 2 years parts and labor warrantee. The heat trace manufacturer shall inspect the heat trace application on site prior to insulation installation.

(4) Insulation

The cable manufacturer shall oversee the insulation of the heat traced piping to ensure the correct thickness of insulation is installed. The supplier shall specify the insulation thicknesses.

(5) Performance

The entire heat traced hot water system shall maintain the temperatures indicated plus or minus 5°F.

(6) Labels

Provide permanent markers on the heat traced piping as indicated elsewhere in the specifications to identify the piping as "Heat Traced."
(7) Power

V/1Ø. Provide 30mA ground fault protection or as required by the manufacturer.

(8) Extent of Tracing

Heat trace all piping to the point where the piping drops in the wall to the fixture or to a point that hot water is available at the fixture within 5 seconds.

(9) Factory Installation

All heating cable, fittings and accessories shall be installed with a factory representative's assistance.

4. GENERAL SPECIALTIES

A. VACUUM BREAKERS AND BACK FLOW PREVENTERS

Where required by the KBC, whether indicated or not, provide approved vacuum breakers or backflow preventers at the following locations.

(1) Where domestic water system connects to fire protection system.

(2) Where domestic water system connects to hydronic system.

(3) At any hose (threaded) tap on the domestic water system.

B. ROOF FLASHINGS

All plumbing vents or other plumbing passing thru the roof shall be flashed as approved by the KBC and as recommended by the roofing manufacturer and/or Contractor.

C. GAS PRESSURE REGULATORS

Provide gas pressure regulators for all gas fired equipment that requires a lower pressure than what is delivered to the appliance. Regulators shall be installed in accordance with the requirements of NFPA 54 and/or International Fuel Gas Code, whichever is more stringent.

END OF SECTION 15400
SECTION 15410 - PLUMBING FIXTURES, FITTINGS AND TRIM

1. GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, General Conditions-Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.

B. The Contractor shall provide all fixtures complete with trim required and connect in a manner conforming to the State Plumbing Code.

C. The Contractor shall obtain exact centerline rough-in dimensions between partitions, walls, etc. as required for lay-out of his rough-in work. All work shall be roughed-in so that all exposed piping will be straight and true without bends or offsets.

D. All exposed piping or in casework below sinks, stops, traps, tailpieces, etc., shall be code approved chrome plated brass unless otherwise indicated or specified. Water supplies shall connect through walls with stops and chrome plated escutcheons with set screws.

E. All fittings, fixtures and trim shall be new unless otherwise indicated or specified. They shall also be of equivalent quality, dimensions, material, etc. as those specified. All faucets, shower heads, drains, levers, trim, etc. shall be constructed of metal and not plastic.

F. Handicapped fixtures shall be mounted as recommended by the KBC and ADA.

G. All fixtures shall be mounted as recommended by the manufacturer. Fixtures shall be rigidly mounted to walls and floors. Pay particular attention to flush valves and bracket concealed portion to building structure during rough-in. Loose, shaky flush valves, lavatories, etc. shall not be acceptable.

H. Prior to final inspection open all faucets and allow to run for fifteen (15) minutes, then remove all faucet aerators and thoroughly clean until smooth flow is obtained.

I. Prior to final inspection, test by operation at least twice:

(1) (Where applicable) adequate flow of hot and/or cold water at;

a. Shower Heads
b. All Faucets
c. Flush Valves and Tanks
d. Tub Drains
e. Hose Bibbs
f. Sill Cocks
g. All Other Valved Hot and/or Cold Water Openings In the Plumbing System
(2) All toilet seats

(3) All flush tank overflows

J. Prior to final inspection, remove all stick-on labels, dirt, grease, other removable stampings, lettering, etc. from plumbing fixtures and thoroughly clean same.

K. All sink and lavatory traps shall have screw in plugs in the bottom for ease of cleaning and have mechanical fittings for ease of removal.

L. All fixtures shall be set level and true and shall be grouted into finished walls, floors, etc. in a neat and workmanlike manner with an approved waterproof non-yellowing grout for such service.

M. Special Note for Handicap Grab Rails: Coordinate top of shower valves, flush valves, flush tank, etc., with location of grab rails as shown on the architectural plans. The Contractor shall install all items to allow for installation, removal and service without removal of the grab bar.

N. All exposed drain pipes and domestic water piping under handicap accessible sinks and lavatories shall be insulated in accordance with ADA requirements and shall have a vinyl plastic covering over all insulation.

O. The Contractor shall obtain a copy of the casework shop drawings and confirm sinks, faucets, gas turrets, etc., will fit in the space provided. Additionally, in ADA applications with handicap sink base cabinets, the Contractor shall limit the total distance from the bottom of the sink to the bottom of the P-trap and coordinate waste pipe rough-in height to ensure the proper installation of the handicap sink base cabinet front closure panel. The Contractor shall not order sinks until he confirms no conflicts occur and shall adjust sink sizes if required. If the Contractor orders sinks, faucets, etc., that do not fit in the casework supplied, he shall replace them at no additional cost.

P. All lavatories, sinks, etc. shall be supplied with center rear drain outlets where necessary to avoid conflict with casework, handicapped kneeboards, etc. If the Contractor orders sinks that do not fit in the casework supplied, he shall replace them at no additional cost.

Q. All single supply faucets shall be provided with mechanical mixing valves unless otherwise noted. Mechanical mixing valves shall have hot and cold water inlet connections, common outlet, in-line check valves, and adjustable temperature setting. Mixing valves shall be Moen model 104424 or equal. Provide one mixing valve per single supply faucet unless otherwise noted. Contractor shall provide all required connections and set mixing valve to required temperature.

R. All gooseneck faucets shall have rigid spouts, unless swing spouts are specified. If swing spouts are specified, the spout shall have a maximum swing of 180 degrees from side to side.

S. All plumbing fixtures shall comply with federal lead free requirements that the lead content of wetted surfaces cannot exceed 0.25% by weight.
T. All water closet handles on ADA water closets shall be located on the approach side of the fixture.

2. FIXTURES AND TRIM

Available Manufacturers: Subject to compliance with requirements of manufacturers offering plumbing fixtures and trim. Plumbing fixtures and trim, which may be incorporated in the work include, but are not limited to, the following:

A. Plumbing Fixtures - Water Closet, Lavatory, Urinal, Bathtubs, Clinical Sink and Scrub Sink
   - American Standard, U.S. Plumbing Products
   - Eljer Plumbingware Div., Wallace-Murray Corp.
   - Kohler Co.
   - Crane Plumbing
   - Universal-Rundle
   - Toto
   - Zurn Co.
   - Sloan Fixtures

B. Plumbing Trim
   - American Standard, U.S. Plumbing Products
   - Chicago Faucet Co.
   - Kohler Co.
   - Delta Co.
   - T&S Brass & Bronze Work Co. (Commercial)
   - Zurn Co.
   - Just Co.
   - Speakman Co.
   - Moen Commercial

C. Flush Valves
   - Delany Co.
   - Sloan Valve Co.
   - Zurn Co.
   - American Standard

D. Fixture Seats
   - Bemis Mfg. Co.
   - Church Seat Co.
   - Olsonite Corp., Olsonite Seats
E. Water Coolers

Elkay Mfg. Co.
Halsey Taylor Div., King-Sealey Thermos Co.
Haws Drinking Faucet Co.
Western Drinking Fountains, Div. of Sunroc Corp.
Oasis Co.
Acorn AQUA

* Acceptable wall hung water coolers shall be equal to Oasis P8AM, Elkay EZS8 or Halsey Taylor HAC8FS. All other wall hung water coolers shall be subject to review of the Engineer.

F. Service Sinks and Mop Basins

American Standard, U.S. Plumbing Products
Eljer Plumbingware Div., Wallace-Murray Corp.
Fiat Products
Kohler Co.
Stern-Williams Co., Inc.
Florestone

G. Stainless Steel Sink

Elkay Mfg. Co.
Just Mfg. Co.
Moen, Div. of Stanadyne/Western
Sterling Co.

H. Fixture Carriers

Josam Mfg. Co.
Jay R. Smith
Tyler Pipe
Zurn Industries
Watts

I. Shower

Bradley Co.
Zurn Co.
Symmons Industries, Inc.
Chicago Faucets
Speakman Company
Powers
Acorn Co.
Moen Commercial

J. Shower Stalls

Clarion
Universal-Rundle
Aqua Bath
Aquarius
Aqua Glass
Acryline
Lasco Bathware

K. Washer/Dryer Connection Box

Guy Gray Co.
Wolverine Brass, Inc.

L. Wash Fountain

Bradley Co.
Acorn Co.
Intersan
Willoughby

M. Emergency Fixtures - Eyewash, Showers

Bradley Co.
Speakman Co.
Guardian Co.

N. P-Trap Insulation Kit (Trap Wrap)

Truebro
Brocar
Plumberex

3. FIXTURE SELECTION

A. Refer to drawings for fixture schedule.
SECTION 15420 - PLUMBING EQUIPMENT

1. GENERAL

A. All plumbing equipment shall comply with the latest provisions of KBC.

2. WATER HEATER

A. See water heater schedule on the drawings sheet P4.0.

3. EXPANSION TANK (DOMESTIC WATER)

A. Amtrol Therm-X-Trol ST-25V expansion tank, 10.3 gallon tank volume, precharged air chamber, stainless steel connection and heavy duty butyl diaphragm.

4. RECIRCULATING DOMESTIC HOT WATER PUMPS

A. Thrush, Armstrong, Bell and Gossett or approved equivalent all bronze in-line centrifugal circulating pump with mechanical seals, drip proof motor and all required overloads, starters and disconnects.

END OF SECTION 15420
SECTION 15500 - FIRE PROTECTION SYSTEM

1. GENERAL

A. The General Conditions, Instructions to Bidders, Section 15000, 1. A, and other Contract Documents are a part of this specification and shall be binding on the Contractor. It shall be the Contractor's responsibility to apprise himself of all information pertinent to his work prior to submitting his proposal. No adjustments will be made in this Contract which is a result of failure to comply with this requirement.

B. No Contractor, other than those regularly engaged in the installation of approved and franchised automatic sprinkler systems, will be considered or approved for the work under this section of the specifications. Bidders must have had not less than five (5) years experience in the fabrication and erection of such systems: wet, dry and rack storage types, and shall have completed installations similar and equivalent in scope to this system under approval by one or more of the recognized Underwriting Associations in the Insurance Field.

C. Before submitting bid, examine all Mechanical, Architectural, and Structural Drawings, visit the site and become acquainted with all conditions that may, in any way whatsoever, affect the execution of this work. Also, the Contractor shall coordinate with the rating bureau and insuring agency to verify adequacy of water supply for the proposed sprinkler system extension.

D. The Contractor shall take his own measurements and be responsible for exact size and location of all openings required for installation of this work. Figured dimensions where indicated are reasonably accurate and should govern in setting out work. Detailed method of installation is not indicated. Where variations exist between described work and approved practice, the Engineer shall be consulted for directive.

E. It is the intent of the Plans and Specifications to provide a general layout only and locate major equipment, piping, etc. Variations in head locations, pipe routing, etc., may be anticipated by the Contractor and shall be coordinated with all other trades and indicated on the drawings and descriptive literature called for hereinafter. It shall be the express responsibility of the Contractor to provide all required materials and equipment and perform all work required to install a complete and approved installation.

F. All materials and methods shall be in accordance with applicable codes, regulations and/or ordinances and meet approval of local inspection authority and the State Fire Marshal. Also, all work shall comply with the latest editions of the National Board of Fire Underwriters, National Fire Protection Association, OSHA Regulations, the National Building Code, the Life Safety Code, IMC Code and the Southern Building Code (Where applicable). The local insuring agency shall review plans prepared and submitted by the Contractor but shall have no authority to make changes once work has begun.

G. All work performed under this section shall be accomplished in close harmony with all other trades. All work not so coordinated shall be removed and reinstalled at the expense of the Contractor.
H. The Contractor shall submit a proposed layout to the Engineer prior to submittal to the Fire Marshal's Office.

2. SCOPE OF WORK

A. Furnish all material, labor, tools, equipment and supervision required for installation of a complete fire protection and stand pipe system as indicated on the project drawings. Include all necessary piping, sprinkler heads, test connections, valves, drains, cabinets, siamese connections, fire hydrants, fire pump, etc.

B. The Contractor shall provide flushing and sterilization of all water lines in accordance with current Kentucky Plumbing Codes, Rules and Regulations and shall make connection to domestic water mains in accord with current rules and regulations of the State Department of Sanitary Engineering and Division of Water.

C. Provide stand pipes with fire hose cabinets or fire valves as indicated or as required to meet the requirements of NFPA and the local fire authority.

D. Provide sprinklers in attics, overhangs, awnings, cooler/freezers, in accessible spaces and all other areas required by NFPA and the local fire authority.

E. Provide dry pipe systems or freeze proof heads as required to provide continuous coverage without freezing.

F. Provide seismic restraints in accordance with the Seismic Restraint specification section 15200.

3. WATER SUPPLIES AND SYSTEM LAYOUT CRITERIA

A. Where flow and pressure data are available, they are indicated on the project drawings. The Contractor shall independently verify all such information and notify the engineer of any discrepancies discovered prior to beginning the work. Where no flow information is indicted on the project drawings, the Contractor shall obtain it and indicate it on the shop drawing submittal. Piping systems shall be hydraulically sized based on the most conservative flow information obtained. No adjustments in the contract amount will be allowed for failure of the Contractor to obtain adequate flow information.

4. DRAWINGS AND DESCRIPTIVE LITERATURE

A. The Contractor shall prepare and submit to the Engineers, seven (7) copies of detailed drawings indicating his proposed Automatic Sprinkler System. These drawings shall indicate minimally the following components when they are used in the system.

(1) Name and address of Owner, Architect and Engineers.
(2) Make and type of sprinkler heads (Catalog cuts).
(3) Make and type of fire department connection (Catalog cuts).
(4) Make and type of post indicator valve (Catalog cuts).
(5) Make and type of detector check valve (Catalog cuts).
(6) Make and type of electric alarm bell (Catalog cuts).
(7) Make and type of retard chamber (Catalog cuts).
(8) Make and type of dry pipe alarm valve (Catalog cuts).
(9) Make and type of flanged check valve (Catalog cuts).
(10) Make and type of flanged gate valve (Catalog cuts).
(11) Make and type of automatic drains (Catalog cuts).
(12) Make and type of pipe hangers (1 catalog cut of each make and/or type).
(13) Make, type and electrical characteristics of:
   a. The pressure sensing switch*.
   b. The post indicator supervisory switch*.
   c. The main gate valve supervisory switch*.
   d. The flow switch*.
   e. Air compressor.
(14) Make and type of fire pump (Catalog cuts).
(15) Make and type of jockey pump (Catalog cuts).
(16) Make and type of supervised O.S & Y valve.
(17) Make and type of indicating butterfly valve.
(18) Make and type of fire hose cabinets.
(19) Make and type of reduced pressure backflow preventer.

Note: All layouts and drawings are to be closely coordinated with the work of all other trades. The Engineers will, upon request, provide a complete set of Architectural, Structural, Mechanical and Electrical Plans and Specifications to aid the Contractor in this work.

*SPECIAL NOTE: 1) The items (indicated by asterisk) must be clearly coordinated with the Fire Alarm System supplier. 2) Supervisory switches located in wet locations (i.e., fire protection vault) shall be provided with NEMA 6 enclosures.

(20) On a set of drawings to the same scale as the drawings accompanying these specifications, indicate:
   a. Each head location coordinated with lights, diffusers and other ceiling mounted device.
   b. Location of all risers, mains, runout lines, etc.
   c. Size of all risers, mains, runout lines, etc.
   d. Location and type of pipe hangers.
   e. All other information required by the Kentucky Department of Housing, Buildings and Construction.

The Contractor shall submit these drawings to the Engineer through the General Contractor/Construction Manager and Architect where applicable. The Contractor shall submit reviewed drawings to the Kentucky Department of Housing, Buildings and Construction for their review and approval. No work shall be done until drawings are approved by the Kentucky Department of HBC.

5. SYSTEM DRAINAGE
A. The entire Standpipe and Sprinkler System (except that part which is below grade and will not freeze) shall be installed so as to allow 100% drainage.

B. All sprinkler branch piping shall be installed so as to drain back to the main riser.

C. Approved 2” drawoff piping shall be provided on sprinkler risers with discharge piping running to nearest floor drain or open air.

D. Where sprinkler piping is trapped, an approved auxiliary draw-off shall be provided and neatly installed.

E. All draw-offs shall have a metal tag labeled "Sprinkler Drain."

6. INSPECTIONS AND TESTS

A. Furnish all labor, equipment and conduct all required tests in the presence of the Owner and Engineer or designated representative.

B. All piping and devices comprising the fire protection system shall be tested under hydrostatic pressure of not less than 200 PSI and maintained for not less than two (2) hours.

C. Upon completion of his work, the Contractor shall submit a written and signed certificate to the Engineers indicating that he performed the above prescribed tests and rectified all malfunctions arising there from.

7. PERMITS

A. The Contractor shall obtain and pay for all necessary state, municipal, county, city and other permits and fees and pay all State taxes which are applicable.

8. GUARANTEE

A. All workmanship, equipment and material shall be guaranteed in writing against defects from any cause, other than misuse, for a period of one year after date of final acceptance.

9. ACCEPTANCE CERTIFICATE

A. Upon completion, the Contractor shall submit to the Engineers, a properly filled out "Sprinkler Contractor's Certificate Covering Materials and Tests." (4 copies).

10. CLEANING

A. Upon completion of this work all debris, material, and equipment shall be removed from the building and premises; all piping shall be cleaned ready for finish painting. Note: Do not remove rust inhibitive primer specified hereinafter.

11. PAINTING
A. All fire protection piping, fittings, etc., shall have one factory or shop coat of rust inhibitive primer. The Contractor shall thoroughly clean all such items in areas where the piping will be exposed so as to readily receive the finish coat specified in the Architectural Division of Painting. Colors shall be as specified in Identification Section of these specifications.

12. PIPE LAYING

A. Bell holes shall be excavated accurately to size and barrel of pipe shall bear firmly on bottom of trench throughout its length. All foreign matter and dirt shall be removed from the inside of the pipe before it is lowered into its position in the trench, and it shall be kept clean by approved means during and after laying. At times when pipe laying is not in progress, the open ends of pipe shall be closed by approved means, and no trench water shall be permitted to enter the pipe. Cutting of pipe, where necessary, shall be done in a neat and workmanlike manner, without damage to pipe. Refer also to Excavation.

13. EQUIPMENT AND MATERIALS

A. Signs

Appropriate code approved and required signs shall be installed on all control valves, drains, inspector's test, etc., indicating the function, installation, etc. Signs shall be neatly affixed with rust inhibitive screws, rivets or where hung from piping; with stainless steel No. 14 AWG wire.

B. Finish

All exposed materials such as valves, fire department connections, sprinkler heads, fire pump test headers, etc., shall be brass or chrome-plated brass.

C. Check Valves

(1) 2-1/2” and over; listed and approved by UL and FM; marked SV-FM; 175# working pressure; 1 BBM; flanged; equivalent to Mueller, Scott or Lunkenheimer.

(2) 2” and under; 150# working pressure; bronze; screwed; equivalent to Jenkins, Scott or Lunkenheimer.

D. Pipe & Fittings

(1) Nipples and fittings shall be of same material, composition, and weight classification as pipe in which installed.

(2) Up to 2” (Interior) Schedule 40 ASTM A-53 black steel; 125# cast iron screwed fittings or Schedule 10, ASTM A-135 black steel with Victaulic or similar type approved fittings.
(3) 2-1/2” and larger (Interior) Schedule 40 black steel with flanged, welded or Victaulic (or similar) type approved fittings or Schedule 10, ASTM A-135 black steel with Victaulic or similar type approved fittings.

(4) Blazemaster or approved equivalent CPVC SDR 13.5 pipe UL listed for fire protection use. CPVC is not allowed for dry pipe systems and is only allowed in light hazard occupancies. Piping must be installed in accordance with the manufacturer’s recommendation and all governing bodies having jurisdiction.

(5) Exterior: Class 200 PVC piping for exterior fire protection piping. Piping shall meet AWWA C900 requirements, be UL listed, Factory Mutual approved and NSF approved. Joints shall have spigot pipe ends with a flexible elastomeric ring seated in a groove to provide water tight seal. Minimum burst pressure to be 900 psi when tested in accordance with ASTM D1599. No. 8 copper wire (tracer wire) shall parallel all exterior PVC pipe.

(6) Dry Pipe System Piping: Same as standard system except Schedule 10 piping is not acceptable.

E. Clamps and Anchors

(1) Furnish and install approved clamps, as required, at all (45 degree) 1/8 bends, (90 degree) 1/4 bends and flange and spigot pieces to the straight pipe to insure permanent anchorage of all fire lines. Clamps, clamp rods, nuts, washers, and glands shall be coated with a quick drying coal tar bituminous paint after installation.

F. Hangers

(1) All piping shall be adequately and permanently supported in an approved manner on approved hangers (Submit with drawings).

G. Sleeves and Escutcheon Plates

(1) Furnish and install sleeves for pipes where piping penetrates masonry walls; exterior wall sleeves to be watertight. Fire and smoke stop all penetrations through fire and smoke walls and coordinate with General Contractor for locations.

(2) Furnish and install cast brass chrome plated split ring type escutcheons where piping penetrates walls, ceilings and floors, whether in finished areas or not.

H. Electric Wiring

(1) All electric wiring for the system which may be required shall be installed in accordance with the National Board of Fire Underwriters, and National Electric Code. The cost of this electric wiring shall be included under this Contract. All electrical wiring and conduit installed in fire protection pits shall be sealed watertight.

I. Inspection Test Connections & Pressure Gauges
(1) A 1" inspection test connection as required by the Kentucky Building Code. Discharge shall run to open air.

(2) Control valve for test connection shall be installed not over 7' above the floor.

(3) A pressure gauge at the inspection. Test connection at each location indicated on the Plans. Pressure gauges shall be 2-1/2" diameter and readable from the floor.

J. Gate Valves

(1) 2-1/2" and over; listed and approved by UL and FM; marked SV-FM; 175# working pressure; 1 BBM; OS&Y; flanged; cast iron discs; bronze seat rings; four point wedging mechanism; equivalent to Mueller, Scott or Lunkenheimer.

(2) 2" and under; 150# working pressure; bronze; rising stem; screwed; bronze discs; bronze seat rings; two point wedging mechanism; equivalent to Jenkins, Scott or Lunkenheimer.

K. Sprinkler Head Cabinet

(1) Furnish and install a cabinet, clearly labeled, with four (4) sprinklers of each type complete with required wrenches. Locate as directed by Engineer. Label "Sprinkler Heads."

L. Fire Department Connection

(1) Furnish and install a fire department connection with threads as approved by the local fire department; cast brass polished and chromium plated; with connection sizes and lettering as directed by the local authority having jurisdiction.

M. Post Indicator Valve

(1) Furnish and install a post indicator valve as required by the local authority. It shall be listed and approved by Underwriters Laboratories and Associated Factory Mutual Laboratories; Marked SV-FM; vertical; non-adjustable; with electric supervisory switch, handle, view window, brass padlock with (2) keys; gate valve to meet gate valve specifications, except to have non-rising stem and mechanical joint ends; equivalent to Mueller, Scott or Lunkenheimer.

N. Detector Check Valve

(1) Furnish and install detector check valve as required by the local authority. It shall be listed and approved by Underwriter Laboratories and Associated Factory Mutual Laboratories; 175# working pressure; IBBM; flanged; with tapped bosses each side for by-pass meter trimming; equivalent to Viking, Badger or Grinnell.
(2) The Contractor shall contact the servicing water company and ascertain their policy pertaining to the by-pass water meter; if not furnished by water company. The Contractor shall furnish and install the by-pass meter and trimming as detailed on the drawings.

O. Sprinkler Heads

Gem, Grinnell, Star, Viking, Reliable, Central or approved equivalent as follows:

(1) Where piping is exposed: "Standard up right."

(2) Where piping is concealed above finished ceilings, provide two pieces, semi recessed, white plated sprinkler heads with removable escutcheon.

(3) Install sprinkler head guards where heads are subject to physical abuse. Heads located below seven (7) feet above floor, etc.

(4) Sprinkler head degree ratings shall be determined by the area serviced in accord with current Codes and Standard Practices. Indicate degree ratings on submitted Shop Drawings.

(5) The Contractor shall submit to the Engineer for inspection, one (1) sample of each type of sprinkler head, proposed to be used on the project.

(6) Where heads are installed in a tile ceiling, they shall be installed in the middle of the tiles, at half or quarter points along the length of the tiles. Install sprinkler heads at quarter points of center scoured 2' X 4' ceiling tiles.

(7) Provide high temperature heads around range hoods, kitchen equipment, kilns, boilers, water heaters and other heat producing equipment.

P. Electric Alarm Bell

(1) Furnish and install electric alarm bell.

Grinnell, Viking, Mueller or equivalent.

Q. Flow Indicator Switches

(1) Furnish and install flow indicator switches as required by NFPA 13. All flow indicator switches shall be UL approved. Coordinate with Fire Alarm System supplier/installer. Provide a set of dry contacts on each flow switch for interface to the Control System if this control point is specified in the Controls Section.

R. Tamper Switches for Water Shut-Off Valves

(1) Furnish and install tamper switches where required by NFPA 13. All tamper switches shall be UL approved. Coordinate with fire alarm system supplier/installer. All tamper switches
located in fire protection pits shall be waterproof, capable of operating beneath water similar to Potter PTS Series and be NFPA approved.

S. Fire Hydrant

(1) Furnish and install fire hydrants as approved by local Fire Department.

14. GUARANTEE

A. All workmanship, equipment and material shall be guaranteed in writing against defects from any cause, other than misuse, or vandalism, for a period of one year after date of final acceptance.

END OF SECTION 15500
SECTION 15530 - COMPRESSED AIR SYSTEM

1. GENERAL

   A. The Contractor shall provide and install in strict compliance with all applicable codes and regulations and with manufacturer's recommendations, all components for complete and functional compressed air systems as shown on the drawings or as specified, herein, including, but not necessarily limited to the following:

      (1) Air Compressors, receivers, after cooler and all required appurtenances, connections, etc.

      (2) Filters, regulators, valves and quick disconnects.

      (3) Compressed air piping.

      (4) Test systems and perform initial equipment starts.

      (5) Flexible pipe connections and vibration isolators.

2. EQUIPMENT

   A. AIR COMPRESSOR AC/1

      (1) Provide a packaged compressed air system as manufactured by Ingersoll-Rand, Quincy, Gardner-Denver, Kellogg-American or approved equivalent. Basic system shall consist of a two-stage, packaged air cooled compressor with motor, storage tank, air dryer, controls and filters. The intent of this specification is to provide a complete compressed air system, either factory or field assembled, ready for connection to power and air piping.

      (2) System shall be equivalent to an Ingersoll-Rand, Model No. T-30. Compressor motor shall be 5 HP, 208V/3Ø/60 HZ. ASME approved receiver shall be designed for 150 PSIG and 80 gallon size.

      (3) Compressor shall be two-stage and deliver 19.7 CFM at 150 PSIG. Controls shall be automatic start-stop.

      (4) Accessories shall be compatible with the compressor as specified above and shall include:

         a. A dry type filter silencer.
         b. An automatic condensate drain valve mounted on the receiver.
         c. An air-cooled after cooler.
         d. A totally enclosed belt guard.
         e. Compressor mounted magnetic motor starting switches.
         f. Provide on the discharge side of the receiver, an Ingersoll-Rand, Filter and an automatic drain valve.
         g. Air Pressure Gauge
(5) Provide on the discharge side of the filter, line size flexible metallic hoses.

(6) Mount compressor on floating inertia base filled with concrete. Base shall be equal in quality to type BMK manufactured by Mason Industries. Base shall be mounted on vibration isolation springs similar to type SLF manufactured by Mason Industries.

B. COMPRESSED AIR PIPING

Schedule 40 black steel with screwed fittings. See Section, Pipe, Pipe Fittings and Pipe Support for additional requirements.

C. COMPRESSED AIR FILTERS - REGULATORS

Near the bottom of all compressed air drops, provide a filter-regulator.

D. COMPRESSED AIR REGULATORS

Regulators shall be DeVilbis, Type HLG, Binks, Schrader, Ingersoll-Rand or approved equivalent. Provide a pressure gauge downstream of each regulator.

E. QUICK DISCONNECTS

Quick disconnects shall be provided on the bottom of all 1/2" compressed air drops designated on the drawings. Disconnects shall be coordinated with Owner to match Owner's requirements.

F. SHUT-OFF COCKS

Provide shut-off cocks for each compressed air drops.

G. FLEXIBLE CONNECTORS

Provide flexible connectors in line with the quick disconnects. Flexible connectors shall be Ingersoll-Rand, Model No. MTHSS050-12, stainless steel "vibraflexor" Mason or approved equivalent. Flexible connectors shall be 1/2" I.P.T. and 12" long.

END OF SECTION 15530
SECTION 15600 - PUMPS

1. GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, General Provisions - Mechanical and to all other contract Documents as they apply to this branch of the work. Attention is also directed to other sections of the specifications which affect the work of this section and which are hereby made a part of the work specified herein.

B. All required motor starters shall be furnished with the respective pump.

C. Electric motors shall be furnished with the pumps and shall be of the size and type scheduled or otherwise specified. All motors shall be UL labeled and shall comply with applicable NEMA standard.

D. Shop drawings shall be submitted as required by Section and shall include complete pump specifications, installation and start-up instructions, current and accurate pump performance curves with the selection points clearly indicated, maintenance data and spare parts lists.

E. Pumps shall be factory tested, cleaned and painted prior to shipment. Size, type, capacity and electrical characteristics are listed in the pump schedule.

F. Insofar as possible, all pumps shall be by the same manufacturer.

G. Pump shall have data plate indicating horsepower, voltage, phase, ampacity, pressure head, and flow rate.

H. Special notes for pumps controlled by variable frequency drives:

   (1) Supplier shall provide the largest non-overloading impeller size for the specified pump motor horsepower, regardless of the specified pump head given on the pump schedule(s).

   (2) Pumps less than 100 HP in size shall be furnished with shaft grounding kit, Aegis SGR Bearing Protection Ring or equal. One shaft grounding ring and related hardware shall be provided on drive end or non-drive end of motor per manufacturer’s instructions. These shall be factory mounted and installed on the exterior of the motor to allow for visual inspection. Ground motor frame per manufacturer’s instructions. Install kit in strict accordance with manufacturer’s instructions.

   (3) Pumps greater than 100 HP to 1000 HP in size shall be furnished with shaft grounding kit, Aegis SGR Bearing Protection Ring or equal. Provide shaft grounding ring on drive end and non-drive end of motor per manufacturer’s instructions. Additionally provide insulated bearing journals to further reduce risk of current dissipation through bearings. Ground motor frame per manufacturer’s instructions. Install kit in strict accordance with manufacturer’s instructions.
2. MATERIAL

A. PUMPS

(1) Manufacturers: Subject to compliance with the specified and scheduled requirements. Pumps by the following manufacturers will be considered:

- Amtrol/Thrush
- Armstrong/Aurora
- Bell and Gossett
- Federal Pump
- Patterson
- Sigmund
- Worthington Pump
- Weinman
- Taco
- FloFab

(2) SELECTIONS:

Refer to the schedule on the plans for base-mounted pump selections.

END OF SECTION 15600
SECTION 15700 - HVAC EQUIPMENT AND HYDRONIC SPECIALTIES

1. GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, General Conditions-Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified herein.

B. The Contractor shall provide in complete working order the following heating, ventilation and air conditioning equipment located as indicated and installed, connected and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.

C. Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer’s Checklist.

D. Factory startup is required for all HVAC equipment. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists. This shall include air handling units, boilers, chillers, cooling towers, VFDs, etc.

E. All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90 and/or International Energy Conservation Code 2012, whichever is more stringent.

F. Installation of all heating, ventilating and air conditioning systems shall be performed by a master HVAC contractor licensed in the state the work will be performed.

G. Note to Suppliers and Manufacturers Representative furnishing proposals for equipment for the project:

   (1) Review the Controls Section of these Specifications (if applicable) to determine controls to be furnished by the equipment manufacturer, if any. The Contractor shall provide all controls with equipment unless specifically listed otherwise.

   (2) Review the section of these specifications entitle: REQUIRED SHOP DRAWINGS, DESCRIPTIVE LITERATURE, MAINTENANCE MANUALS, PARTS LISTS, SPECIAL KEYS, TOOLS, ETC., and provide all documents called for therein.

   (3) Ensure that the equipment which you propose to furnish may be installed, connected, placed in operation and easily maintained at the location and in the space allocated for it.

   (4) Determine from the Bid Documents the date of completion of this project and ensure that equipment delivery schedules can be met so as to allow this completion date to be met.
(5) Where manufacturers’ temperature controls are specified, they shall be in full compliance with International Mechanical Code Section 606 including automatic smoke shut down provisions.

(6) Provide factory start-up on site by a factory representative (not a third party contractor) for all HVAC equipment, including pumps, VFDS, boilers, chillers, cooling towers, heat pumps, rooftop units, etc. Submit factory start-up reports to the Engineer.

(7) Provide training to the Owner by a factory representative for each type of equipment. Training shall be a minimum of eight (8) hours on site and the Engineer shall be notified one (1) week in advance of the training. Training shall only occur when the systems are complete and 100% functional. All training shall be video taped.

(8) Review the Section on Motor Starters and Electrical Requirements for Mechanical Equipment.

(9) Requirements for motors controlled by variable frequency drives:
   
   a. All motors shall be inverter duty rated.

   b. Motors less than 100 HP in size shall be furnished with shaft grounding kit, Aegis SGR Bearing Protection Ring or equal. One shaft grounding ring and related hardware shall be provided on drive end or non-drive end of motor per manufacturer’s instructions. These shall be factory mounted and installed on the exterior of the motor to allow for visual inspection. Ground motor frame per manufacturer’s instructions. Install kit in strict accordance with manufacturer’s instructions.

   c. Motors greater than 100 HP to 1000 HP in size shall be furnished with shaft grounding kit, Aegis SGR Bearing Protection Ring or equal. Provide shaft grounding ring on drive end and non-drive end of motor per manufacturer’s instructions. Additionally provide insulated bearing journals to further reduce risk of current dissipation through bearings. Ground motor frame per manufacturer’s instructions. Install kit in strict accordance with manufacturer’s instructions.

(10) Type 1 kitchen exhaust hoods shall be provided with a heat sensor per IMC 2006, section 507.2.1.1, to enable the exhaust and make-up air system automatically upon detection of heat.

(11) Equipment incorporating energy recovery wheels shall be provided with an aluminum wheel with molecular sieve desiccant, 4 angstrom maximum sieve size. Wheels shall be certified in accordance with ASHRAE 84 or ARI 1060 standards.

(12) All condensate producing equipment shall be provided with a condensate trap as recommended by the equipment manufacturer and a condensate overflow switch.

(13) Provide low ambient and all required controls and accessories on all HVAC equipment to ensure they can provide cooling during the winter season.

(14) All outdoor HVAC equipment shall be provided with hail guards.
(15) Provide a complete air tight enclosure with opening door that seals air tight for all filters on air moving equipment.

(16) All equipment shall be furnished for a single point electrical connection unless specifically excluded as a requirement.

2. EQUIPMENT

A. BOILER B-1A & B

(1) GENERAL

A. Supply and install modulating and condensing boiler(s) as specified herein.

B. Each boiler shall be factory assembled and tested. Each boiler shall be shipped self-contained and ready for operation except for connection at the installation site of heating piping, fuel, electrical, combustion air, exhaust venting, condensate drainage and relief valve discharge piping.

C. The boiler shall be capable of operating on natural gas. The boiler shall be capable of normal operation and full rated input with natural gas supply pressure between 4 inches w.c. [1.0kPa] and 10.5 inches w.c. [2.6kPa], or LP gas supply pressure between 8 inches w.c. [2.0kPa] and 13 inches w.c [3.2kPa]. The boiler shall be factory set for natural gas, and shall include a factory-supplied kit for field conversion to LP gas operation.


E. The boiler shall be certified for installation with zero clearance to combustibles, and shall be certified for closet and alcove installation when vented in accordance with the manufacturer’s instructions.

F. The boiler stainless steel heat engine shall be designed and constructed in compliance with the ASME Boiler and Pressure Vessel Code Section IV. A permanent nameplate bearing the “H” stamp and National Board registration number shall be attached to the heat engine in a readily viewable location.

G. The heat engine shall have a limited lifetime warranty. All other parts shall have a five year limited warranty covering defects in materials and workmanship. The warranty period is based from the date of manufacture or one year from date of installation (which ever period is longer). (effective 2014-03-06)

(2) PRODUCT

A. Acceptable manufacturers

1. The boiler shall be a Trinity Tft manufactured by NY Thermal Inc. (NTI).

B. Boiler Construction

   (a) Heat Engine

   (b) The heat engine shall be a vertical firetube down-fired design. The combustion chamber, firetubes, tubesheets and shell shall be constructed of Type 439 (ASME SA240, UNS S43932) stainless steel. The heat engine assembly shall be of all-welded construction. The heat engine for models Tft60-110 shall be rated for 30psi
[206.8kPa] maximum operating pressure. The heat engine for models Tft155-399 shall be rated for 80psi [551.6kPa] maximum operating pressure.

(c) The heat engine shall be able to accept up to 35% mixture of inhibited propylene glycol HVAC antifreeze, without damage to the heat engine or other components.

(d) The heat engine shall be accessible for inspection and cleaning via a removable burner access cover. The cover shall include a flame observation port.

(e) The heat engine shall be provided with an automatic air vent (field installed).

(f) A factory-supplied field-installed anti-siphon trap shall be connected to the combustion chamber for collection and removal of condensate. The trap shall be translucent to permit visual inspection and shall be easily disassembled for cleaning.

C. Gas Train and Combustion System

a. The combustion system shall be fully modulating with a____:1 turndown ratio.

b. The combustion system shall contain:
   i. Adjustable air/gas ratio valve with integral regulator
   ii. Mixing venturi
   iii. Variable speed blower utilizing pulse width modulation
   iv. Stainless steel cylindrical premix burner with woven stainless steel mesh covering
   v. Dual-electrode spark igniter
   vi. Independent flame sensing electrode.

D. Venting and Combustion Air

a. The boiler shall be designed for venting with 3” inch diameter Schedule 40 CPVC.

b. The combustion chamber exhaust outlet shall include a ½” [12mm] diameter port with a removable EPDM plug to permit insertion of a combustion analyzer probe.

E. Cabinet

a. The unit internal structure shall be constructed of 16ga galvanized steel.

b. The cabinet jacket shall be constructed of removable panels fabricated from 20ga steel finished with a durable factory applied coating on both sides. Removal of jacket panels shall not compromise sealing of the combustion chamber.

F. Electrical

a. The boiler shall operate from a 120VAC/1 phase/60Hz power supply with a current draw of 12A.

b. A line-voltage barrier strip shall be provided for connection of supply power and up to three (3) circulator pumps. The boiler shall be capable of powering each pump up to a maximum of 1/6HP or 3 Amps @ 120VAC.

c. Two (2) low-voltage barrier strips shall be provided. One shall be for connection of:
   i. Outdoor temperature sensor
ii. System temperature sensor
iii. DHW indirect tank aquastat or DHW temperature sensor
iv. 4-20mA signal from external control for burner modulation
v. EIA-485 communication for Lead-Lag cascade control.

The second low-voltage barrier strip shall be for connection of:

1) Two (2) heating thermostats
2) External safety limit
3) Alarm signal to a building automation system

G. Controls

a. The boiler control system shall operate on 24VAC provided by an internal 40VA transformer.

b. The integrated microprocessor-based controller shall incorporate all operational and safety control functions, including:
   i. Burner spark ignition
   ii. Flame detection and supervision
   iii. Burner firing rate modulation
   iv. High temperature limit (UL353 rated)

c. The controller shall incorporate a proportional-integral-derivative (PID) algorithm for three (3) separate temperature controls: two (2) for space heating with independent setpoints; one (1) for domestic hot water.

d. The controller shall permit field selection of the boiler control response to a high temperature limit excursion to either Lockout or Recycle and Delay. The factory set response shall be Recycle and Delay.

e. The controller shall provide:
   i. Operation of up to three (3) pumps: Boiler, Central Heating and Indirect Domestic Hot Water
   ii. Domestic hot water prioritization with a field-adjustable priority time
   iii. Field-adjustable outdoor reset to automatically set system water temperature based on outdoor air temperature. An outdoor sensor shall be factory-supplied for field installation
   iv. Manual firing rate control, adjustable between minimum and maximum firing rate
   v. Warm weather shutdown to disable heating, with field adjustable setpoint
   vi. Pump exercise for 10 seconds at 24 hour intervals
   vii. Freeze protection to operate the boiler and central heat pumps when outlet water temperature falls below 45°F [7.2°C], and fire the burner at minimum modulation when the outlet temperature falls below 38°F [3.3°C]
   viii. Field setting of the following:
      1. Low temperature central heat (CH1) setpoint from 60°F [15°C] to 190°F [88°C]
      2. High temperature central heat (CH2) setpoint from 60°F [15°C] to 190°F [88°C]
      3. Outdoor reset parameters – low temperature central heating
      4. Outdoor reset parameters – high temperature central heating
5. Domestic hot water (DHW) setpoint from 60°F [15.6°C] to 190°F [88°C]
6. Boiler pump overrun time from 0 to 30 minutes
7. CH and DHW pump overrun time from 0 to 10 seconds
8. CH and DHW pump start delay from 0 to 5 seconds
9. Warm weather shutdown (WWSD) temperature from 50°F [10°C] to 90°F [32.2°C]
10. DHW priority override timer from 0 to 18 hours
11. CH modulation source (inlet, outlet or system water temperature)
12. DHW modulation source (DHW indirect tank, inlet or outlet water temperature)
13. Lead and lag selection method (sequence order or measured runtime)
14. Lead rotation time from 0 to 960 hours
15. Slave order priority method (equalize runtime, use first or use last)
16. Anti short-cycle interval from 0 to 60 minutes
17. Temperature units, °F or °C.

f. The control system shall include a built-in colour touchscreen display to permit monitoring of unit operation and field adjustment of control parameters. The control shall support three (3) levels of password-protected access permission: User (no password), Installer, and OEM. The display shall be capable of showing:
   i. Heat demand source
   ii. Burner state
   iii. Demanded firing rate in RPM
   iv. Actual blower RPM
   v. Current setpoint
   vi. Heat engine entering water temperature
   vii. Heat engine exiting water temperature
   viii. Exhaust gas temperature
   ix. Outdoor Temperature

g. The controller shall be capable of Lead-Lag staging and rotation of up to eight (8) Tft-series boilers with no additional control hardware required, apart from the necessary field-supplied cabling to connect the units via terminals provided on the low-voltage barrier strip. Field configuration of Lead-Lag operation shall be accomplished through the built-in touchscreen display.

h. The controller shall provide integrated communication capability using the Modbus RTU protocol over an EIA-485 interface. Communication with external third-party building management networks utilizing BACnet MS/TP, BACnet/IP, Johnson Metasys N2, or LonWorks protocol shall be accomplished with factory-option NTI communication gateway(s). The gateway shall map factory-selected internal controller data registers to (select one): BACnet objects, Johnson Metasys N2 data points or LonWorks SNVTs. The gateway shall:
   a) communicate with the boiler controller(s) at 38,400 bits/second
   b) be equipped with DIP switches for field selection of node address and protocol
   c) auto-discover Modbus addresses of up to 8 connected boilers.

i. When two (2) or more boilers are connected in a Lead-Lag cascade configuration, the control shall allow for connection of an outdoor temperature sensor on any slave unit,
thereby permitting connection of a system temperature sensor on the master unit.

C. Trim kit

2. The following shall be factory supplied with each boiler, for field installation:
   (a) Qty. 1 - Outdoor air temperature sensor, 10k thermistor
   (b) Qty. 1 - Pressure gauge, 0-30psi
   (c) Qty. 1 - ¾ inch NPT ASME relief valve, 30psi
   (d) Qty. 1 - LP conversion kit
   (e) Qty. 2 - 1/8 x ¾ inch Bushing, Brass
   (f) Qty. 1 - 5 inch length, _ inch CPVC Schedule 40 pipe
   (g) Qty. 1 - ½ x _ inch NPT Tee
   (h) Qty. 2 - _ inch diameter anti-bird screen
   (i) Qty. 1 - Wall Mount Bottom Support Bracket

D. Manuals

3. Each boiler shall include the following manuals:
   (a) Installation and Operating (I&O) manual
   (b) Controller and display reference manual
   (c) application manual

(3) INSTALLATION

A. Boiler shall be installed and vented in accordance with manufacturers’ instructions.

B. Venting

1. The boiler shall be vented as shown on the plans and specified below:
   (a) Venting method (select one):
      1) Sidewall Direct Vent with exterior termination of separate exhaust and combustion air pipes
      2) Sidewall Direct Vent with termination by manufacturer specified sidewall termination kit of separate exhaust and combustion air pipes
      3) Sidewall Direct Vent with termination by manufacturer specified concentric vent termination kit of separate exhaust and combustion air pipes
      4) Vertical Direct Vent with exterior roof-top termination of separate exhaust and combustion air pipes
      5) Vertical Direct Vent with termination by manufacturer specified concentric vent termination kit of separate exhaust and combustion air pipes
   (b) Exhaust venting
      6) Foam Core pipe is not an approved exhaust vent material and shall not be used.
      7) Exhaust vent material shall be
         (i) 4” inch diameter stainless steel pipe
   (c) Combustion air inlet
      8) Combustion air inlet material shall be
         (i) 4, Schedule 40 CPVC pipe, including fittings.

B. ENERGY RECOVERY UNIT (OA-1)
1. Heat Pump

a. Heat pump systems shall be designed to provide capacity control from 10-100% in both heating and cooling mode. Hot gas bypass or unit staging options shall not be allowed as a means for capacity control. The heat pump shall not require reverse cycle system defrost of any type for outdoor air temperatures below 0°F. The heat pump shall be configured to utilize waste heat energy from the building exhaust for conditioning of the entering outdoor air stream. Hermetic compressors shall include a scroll design with internal pressure relief and motor temperature winding protection. Units shall be equipped with reversal rotation protection. The system coils shall have an SHR less than 0.75 insuring proper dehumidification of the outdoor air stream. All Coils shall be leak tested and charged at the factory for immediate operation upon installation and check-out of the unit. Refrigeration control shall include thermal expansion valves, external equalizers and distributors, check valves, system reversing valves and all other necessary components to insure proper operation. Refrigeration protection shall include low and high pressure switches, refrigerant circuit frost protection, liquid line filters/dryers and service gage ports. The supply air coil shall have a corrosion proof drain pan with 1/8" slope for proper draining of the condensate. The unit shall allow proper condensate trapping external of the unit. The drain pan shall be completely accessible for cleaning. The unit shall have 2" filter racks with MERV 8 filters in each air stream before the wheel and coils. The unit shall have direct access to each filter section for inspection and changing of the filters. The unit control system shall monitor critical heat pump system parameters and shut off the system whenever an alarm occurs: The system shall indicate the following failures: high discharge temperature, excessive compressor current, locked rotor, demand signal loss, discharge thermistor fault, welded contactor, low supply voltage. The refrigerant system shall have an adjustable 5 minute minimum ON and minimum OFF timer circuit protection. The refrigerant circuit shall have an anti-cycle time in addition to the minimum ON/OFF timer that prevents the compressors from cycling on the minimum timer circuit. The unit shall be fully operational from -10°F thru 115°F ambient conditions.

2. Enthalpy Wheel

a. The system shall utilize a total enthalpy wheel to capture waste heat energy from the building exhaust air stream for conditioning of the entering outdoor air stream. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt. The wheel shall not allow more than 5% crossover between the supply and exhaust air stream. The total energy recovery wheel shall be coated with silica gel desiccant permanently bonded without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity. The wheel shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow and minimum pressure drop-to-efficiency ratios. The layers shall be effectively captured in stainless steel wheel frames or aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix. The wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless,
plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment. The energy recovery cassette shall be an underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an underwriters Laboratory recognized component and shall be mounted in the cassette frame and supplied with a service connector or junction box.

3. Blowers

   a. The unit supply fan shall consist of centrifugal backward curve fan with 96% efficiency electronically commutated motor (ECM). The motor RPM shall be directly set by the package unit control system. The balancing contractor shall have direct access to set the motor RPM through the unit mounted control system display. The unit exhaust fan shall consist of a centrifugal backward curve fan with 96% efficiency electronic control motor. Each supply and exhaust fan shall have a differential pressure switch to indicate fan air flow status to the units control system. The unit supply and return air shall be horizontal discharge with flanged duct connections. The unit shall allow horizontal discharge without the need for curb or other mount.

4. Additional Heat

   a. Manufacturer to provide factory installed electric resistance heat for the unit located in the outdoor air stream. Unit shall include field-replaceable heat sections. Unit shall include a 10kW electric resistance heating section using open element with insulated ceramic bushing, contactors, auto reset high temperature limit switch and other necessary safety devices.

5. Cabinet

   a. Outer casing shall be fabricated from G90 galvanized steel substrate with 60 gloss painted finish coat. Structural members shall be 18 gauge with access doors for the following sections: intake air filters, exhaust air filters, supply and exhaust fans, evaporator and condenser coils, drain pan, compressor, power connections, and unit controls. Roof panels shall be 20 gauge with double-wall 1” insulation liner. The cabinet design shall prevent condensation forming on the outside of the unit casing in operation. Access panel doors shall be fully- gasketed. Access panel door to the supply fan shall be of double-wall construction. Cabinet and mounting base shall be arranged for both indoor and outdoor installation. The unit control panel section shall be laid out to provide separation of high and low voltage components per uL standards. For ease of service, all electrical components shall be clearly identified with 1/2” diameter self adhesive labels to match the unit specific wiring diagram.

6. Controls
a. The unit shall have a fully integrated control system that directly controls the heat pump, enthalpy wheel and fans to condition the entering air stream. The unit shall have a factory mounted display that indicates all unit status, parameters and alarms. The displays shall allow complete access to unit setpoints and mode. The control system shall allow normal operations, manual test mode, automatic test mode and alarm mode operation. The air balancing contractor shall have access to the control system to set the unit CFM by adjusting the fan motor RPM. The control system shall allow users to change the discharge air setpoints, allow unit time scheduling and reviewing of alarm conditions. The unit shall have bacNet or Lon allowing interface to an external building automation system.

7. Certifications

a. The unit shall be tested to ARI standard 210/240 and 920p. The unit shall be design certified by a nationally recognized testing lab. The enthalpy wheel cassette shall be listed in the ARI Certified Products Directory and bear the ARI Certified Product Seal.

8. Warranty

a. Manufacturer must have at least 20 years experience in manufacturing ventilation air equipment. The unit shall carry a five (5) year limited warranty on all parts and component

C. MAKE-UP AIR UNIT (MAU-1)

(1) Summary

a. This section includes units with integral Direct Gas-Fired heatingAirflow arrangement shall be Outdoor Air with Variable Air Volume. Each unit shall be constructed in a horizontal configuration and shall incorporate additional product requirements as listed in Section 2 of this specification.
b. Related sections include the following:
   (1) Section 15010: Scope of Work
   (2) Section 15000: General Provisions
   (3) Section 15080: Insulation
   (4) Section 15100: Pipes
   (5) Section 15900: Controls and Instrumentation
   (6) Section 16000: Electrical

(2) Submittals

a. Product Data: For each type or model, include the following:
   1. Complete fan performance curves for Supply Air, with system operating conditions indicated, as tested in an AMCA Certified Chamber.
2. Sound performance data for Supply Air, as tested in an AMCA Certified chamber.

3. Motor ratings, electrical characteristics and motor and fan accessories.

4. Dimensioned drawings for each type of installation, showing isometric and plan views, to include location of attached ductwork and service clearance requirements.

5. Estimated gross weight of each installed unit.

6. Installation, Operating and Maintenance manual (IOM) for each model.

7. Remote Panel description to include all functions.

(3) Quality Assurance

a. Source Limitations: Obtain Packaged Make-Up Air Unit with Integral Heating with all appurtenant components or accessories from a single manufacturer.

b. Product Options: Drawings must indicate size, profiles and dimensional requirements of Make-Up Air Units and are to be based on the specific system indicated. Refer to Division 1 Section "Product Requirements".

c. Certifications:

   i. Entire unit shall be ETL Certified per ANSI Z83.4 or ANSI Z83.18 and bear an ETL mark.

(4) COORDINATION

a. Coordinate size and location of all building penetrations required for installation of each unit and associated ducting, plumbing and electrical systems.

b. Coordinate sequencing of construction of associated plumbing, HVAC, and electrical supply.

(5) Products

a. Manufacturers

   i. Available Manufacturers: Subject to compliance with specifications contained within this document, manufacturers offering products that may be incorporated into the work include, but are not limited to:

      1. Greenheck Fan Corporation

(6) Manufactured Units
a. Units with Integral Heating shall be fully assembled at the factory and consist of an insulated metal cabinet, a motorized intake damper, supply air blower assembly, electrical control center. All specified components and internal accessories factory installed and tested and prepared for single-point high voltage connection.

(7) Cabinet

a. Materials: Formed, double wall insulated metal cabinet, fabricated to permit access to internal components for maintenance. Underside of MAU shall have formed metal panels covering base panel insulation.

   i. Outside casing: 18 gauge, galvanized (G90) steel meeting ASTM A653 for components that do not receive a painted finish. Pre-painted components as supplied by the factory shall have polyester urethane paint on 18 gauge G60 galvanized steel. Base rail is 12 gauge, galvanized (G90) steel.

   ii. Internal Assemblies: 24 gauge galvanized (G90) steel except for motor supports which shall be minimum 14 gauge galvanized (G90) steel.

   iii. Cabinet Insulation: Comply with NFPA 90A and NFPA 90B and erosion requirements of UL 181.

   iv. Materials: Fiberglass insulation. If insulation other than fiberglass is used, it must also meet the Fire Hazard Classification shown below.

1. Thickness: 1 inch (25 mm)

2. Fire Hazard Classification: Maximum flame spread of 25 and smoke developed of 50, when tested in accordance with ASTM C 411.

3. Location and application: Floor of each unit shall be insulated with fiberglass insulation. Full interior coverage from "Heating on".

4. Access panels: Unit shall be equipped with insulated hinged access panels to provide easy access to all major components. Access panels shall be fabricated of 18 gauge galvanized G90 steel.

5. Supply Air blower assembly options:

   a. Forward curve blower: Blower assembly consists of an electric motor and a belt driven, double width, and double inlet forward curve blower. Assembly shall be mounted on heavy gauge
galvanized rails and further mounted on minimum 1.125 inch thick neoprene vibration isolators.

6. Control center / connections:

a. Unit shall have an electrical control center where all high and low voltage connections are made. Control center shall be constructed to permit single-point high voltage power supply connections.

7. Direct Gas-Fired Furnace:

a. Unit shall be factory assembled, piped, and wired. Direct gas-fired system will be 92% efficient while supplying a burner that is capable of providing 25:1 turndown. Unit will utilize a draw through design and incorporate adjustable burner baffles plates for field adjustments. Unit will have a EconomyPilot ignition system.

b. Burner construction shall consist of a cast aluminum burner manifold and 400 series stainless steel mixing plates. No air from inside the space shall be allowed to pass across the burner at any time. Flame sensing shall be provided by a flame rod. Burner control shall have a digital coded fault indicator capable of storing the last five faults.

c. Shall be equipped for operation on Natural gas with a maximum rated inlet gas pressure of 1/2 PSI. An external gas pressure regulator shall be provided by the factory.

d. Burner control option to include the following: Room temperature.

e. Shall include the following safety controls:

i. Manual Reset, High Limit Switch: Main gas valve closes if high-limit temperature is exceeded.

ii. Dual safety shutoff valves shall be provided that do not exceed 120 VAC control signals.

iii. High Gas Pressure Switch(es): Main gas valve closes if high pressure switch defaults.
iv. Low Gas Pressure Switch(es): Main gas valve closes if low pressure switch defaults.

f. Motorized Inlet Air Dampers: to be of low leakage type and shall be factory installed.

g. Sensors are considered to be part of various optional operational modes or device controllers and are to be factory supplied and installed as specified by the A/E.


   a. Blower-Fc

      i. Blower section construction, Supply Air: Belt drive motor and blower shall be assembled onto a minimum 14 gauge galvanized steel platform and must have neoprene vibration isolation devices, minimum of 1-1/8 inches thick.

      ii. Blower assemblies: Shall be statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and horsepower.

      iii. Centrifugal blower housing: Formed and reinforced steel panels to make curved scroll housing with shaped cutoff.

      iv. Forward curved blower (fan) wheels: Galvanized or aluminum construction with inlet flange and shallow blades curved forward in direction of airflow. Mechanically attached to shaft with set screws.

      v. Blower section motor source quality control: Blower performance shall be factory tested for flow rate, pressure, power, air density, rotation speed and efficiency. Ratings are to be established in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Rating”.

9. Motors

   a. General: Blower motors greater than 3/4 horsepower shall be "NEMA Premium" unless otherwise indicated. Compliance with EPAct minimum energy-efficiency standards for single speed ODP and TE enclosures is not acceptable. Motors shall be heavy-duty,
permanently lubricated type to match the fan load and furnished at the specified voltage, phase, and enclosure.

b. Motors shall be 60 cycle, 3 phase, 208 volt.

10. Unit Controls

a. The unit shall be constructed so that it can function as a stand-alone heating system controlled by a factory-supplied remote panel, thermostats and sensors or it can be operated as a heating system controlled by a Building Management System (BMS).

b. Variable Frequency Drive (VFD): Unit shall have factory installed variable frequency drives for modulation of the blower motors. The VFDs shall be factory-programmed for unit-specific requirements and shall not require additional field programming to operate.

c. Remote Panel: Manufacturer shall provide and contractor shall install an Industrial type remote panel that functions as a remote indicator of owner-selected operating parameters and also permits remote inputting of new operating parameters.

11. Sensors to be provided with the unit:

a. Room/Space Temperature Sensors

b. Heating Inlet Air Sensor

c. Dirty Filter Sensor

12. Filters

a. Unit shall have 2" thick MERV 13 disposable pleated filters following the outdoor air intake in a V-bank arrangement and shall be accessible from the exterior of the unit.

b. Execution

i. Examination
1. Prior to start of installation, examine area and conditions to verify correct location for compliance with installation tolerances and other conditions affecting unit performance. See unit IOM.

2. Proceed with installation only after all unsatisfactory conditions have been corrected.

c. Installation

i. Installation shall be accomplished in accordance with these written specifications, project drawings, manufacturer's installation instructions as documented in manufacturer's IOM, Best Practices and all applicable building codes.

d. Connections

i. In all cases, industry Best Practices shall be incorporated. Connections are to be made subject to the installation requirements shown above.

ii. Piping installation requirements are specified in Division 22 (Plumbing). Drawings indicate general arrangement of piping, fittings and specialties.

iii. Duct installation and connection requirements are specified in Division 23 of this document.

iv. Electrical installation requirements are specified in Division 26 of this document.

e. Field Quality Control

i. Manufacturer's Field Service: Engage a factory authorized service representative to inspect field assembled components and equipment installation, to include electrical and piping connections. Report results to A/E in writing. Inspection must include a complete startup checklist to include (as a minimum) the following: Completed Start-Up Checklists as found in manufacturer's IOM.

f. Start-Up Service

i. Engage a factory authorized service representative to perform startup service. Clean entire unit, comb coil fins as necessary, and install clean filters. Verify water source for compliance with manufacturer's requirements for flow and temperature. Measure and record electrical values for voltage and amperage. Refer to Division 23 "Testing, Adjusting and Balancing" and comply with provisions therein.
g. Demonstration and Training

i. Engage a factory authorized service representative to train owner's maintenance personnel to adjust, operate and maintain the entire Make-Up Air unit. Refer to Division 01 Section Closeout Procedures and Demonstration and Training.

D. SPLIT SYSTEM HEAT PUMP

(1) General
   a. The 4TWR7 is fully charged from the factory for matched indoor section and up to 15 feet of piping. This unit is designed to operate at outdoor ambient temperatures as high as 115°F. Cooling capacities are matched with a wide selection of air handlers and furnace coils that are AHRI certified. The unit shall be certified to UL 1995. Exterior is designed for outdoor application.

(2) Casing
   a. Unit casing is constructed of heavy gauge, G60 galvanized steel and painted with a weather-resistant powder paint on all louvers and panels. Corrosion and weatherproof CMBP-G30 DuraTuff™ base.

(3) Refrigerant Controls
   a. Refrigeration system controls include condenser fan, compressor contactor and high pressure switch. High and low pressure controls are inherent to the compressor. A factory installed liquid line drier is standard.

(4) Compressor
   a. The Climatuff® 2-stage compressor features internal over temperature and pressure protection and hermetic motor. Other features include: centrifugal oil pump and modular plugs for electrical connections.

(5) Condenser Coil
   a. The outdoor coil provides low airflow resistance and efficient heat transfer. The coil is protected on all four sides by louvered panels.
   b. Low Ambient Cooling
      1) As manufactured, this unit has a cooling capability to 55°F.

(6) S9V2 Furnace – HP-24, HP-60
   a. Natural Gas Models
      1) Central Heating furnace designs are certified by the American Gas Association for both natural and L.P. gas. Limit setting and rating data were established and approved under standard rating conditions using American National Standards Institute standards.
   b. Safe Operation
      1) The Integrated System Control is a solid state device which continuously monitors for presence of flame when the system is in the heating mode of operation. Dual solenoid combination gas valve and regulator provide additional safety.
c. Quick Heating
   1) Durable, cycle tested, heavy gauge tubular stainless steel primary heat exchanger quickly transfers heat to provide warm conditioned air to the structure. Low energy power vent blower, to increase efficiency and provide a positive discharge of gas fumes to the outside.

d. Burners
   1) Multiport Inshot burners. All models can be converted to L.P. gas with LP conversion kit.

e. Energy Efficient Operation
   1) Furnace is certified by the manufacturer to leak 1% or less of nominal air conditioning CFM delivered when pressurized to .5" water column with all inlets, outlets, and drains sealed.

f. Secondary Heat Exchanger
   1) The S-Series furnace has a special type 29-4C™ stainless steel secondary heat exchanger to reclaim heat from flue gases which would normally be lost.

g. Styling
   1) Heavy gauge steel and "wrap-around" cabinet construction is used in the cabinet with baked on enamel finish for strength and beauty. Every orientation has at least two venting options. There are no knockouts on cabinet.

h. Features and General Operation
   1) The S-Series furnace utilizes a Silicon Nitride Hot Surface Ignition system. The integrated system control lights the main burners upon a demand for heat from the room thermostat. Complete front service access.
      (a) Low energy power vent burners
      (b) Vent proving pressure switches.
      (c) 96.0% AFUE
      (d) 3-WAY MULTI-POISE
      (e) 1% or less air leakage as per ASHRAE 193 Open vestibule design provides a full 34” high openvestibule
      (f) Tubular Stainless Steel Primary Heat Exchanger 29-4C Stainless Steel Secondary Heat Exchanger

i. 4TXC DX Coil – HP-24, HP-60
   1) General
      (a) Upflow, Downflow, or Horizontal coils shall be designed for cooling and heat pump applications. The coil shall be 3/8” seamless aluminum tubing mechanically bonded to aluminum plate fin. Refrigerant for the 4TXC-DS coils shall be controlled with factory installed Non-Bleed TXV refrigerant control. Refrigerant connections are brazed fittings with an additional Schrader Valve for system service. The coil cabinet shall have a removable front and interior access panel for evaporator coil entering air surface cleaning. The coil includes a drain pan with drain connections for
vertical or horizontal operation and a horizontal auxiliary drain pan. A.R.I. certified with matching condensing units.

2) Accessories
   (a) Evaporator Defrost Control installed on coil for lower ambient operating conditions.

E. VENTILATING FANS

(1) Ventilating fans shall be of the type, capacity, size, etc. here-in-after scheduled. Catalog numbers are listed as design criteria only. Alternate selections will be accepted provided quality, function, etc. are equivalent. All fans shall be UL listed, complete with all required disconnects and starters and shall be AMCA rated and certified. Model numbers listed are Greenheck, acceptable alternates are Penn, Carnes, Acme, Shipman, Jenn-Aire and Loren-Cook. The Architect shall select the color for all exposed fans.

(2) Selection

Refer to the schedule on the plans.

F. COMBINATION VARIABLE FREQUENCY DRIVE / DISCONNECT (VFD) FOR MOTORS 50 HP AND LESS

   (1) Manufacturers

   a. Danfoss Graham VLT 6000 Series, Reliance, Yaskawa, Emerson, ABB, or approved equal.

   (3) General

   a. Furnish complete variable frequency VFDs as specified herein for the fans and pumps designated on the drawing schedules to be variable speed. All standard and optional features shall be included within the VFD enclosure, unless otherwise specified. VFD shall be housed in a metal NEMA enclosure of type according to the installation and operating conditions at the job site. The VFD’s UL listing shall allow mounting in plenum or other air handling compartments. If a NEMA 12 enclosure is required for the plenum rating, the manufacturer must supply a NEMA 12 rated VFD.

   b. The VFD shall have integral disconnecting means to disconnect power to device in accordance with NEC.

   c. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump and fan control and to eliminate the need for motor derating.

   d. With the motor’s rated voltage applied to the VFD input, the VFD shall allow the motor to produce full rated power at rated amps, RMS fundamental volts, and speed without using
the motor’s service factor. VFDs utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.

e. The VFD shall include an input full-wave bridge rectifier and maintain a fundamental power factor near unity regardless of speed or load.

f. The VFD and options shall be tested to ANSI/UL Standard 508. The complete VFD, including all specified options, shall be assembled by the manufacturer, which shall be UL-508 certified for the building and assembly of option panels. Assembly of the option panels by a third-party panel shop is not acceptable. The appropriate UL stickers shall be applied to both the VFD and option panel, in the case where these are not contained in one panel. When these VFDs are to be located in Canada, CSA or C-UL certifications shall apply. Both VFD and option panel shall be manufactured in ISO 9001 certified facilities.

g. The VFD shall have a dual 5% DC link reactor on the positive and negative rails of the DC bus to minimize power line harmonics and protect the drive from power line transients. The reactor shall be non-saturating (linear) to provide full harmonic filtering throughout the entire load range. VFDs with saturating (non-linear) DC link reactors shall require an additional 3% AC line reactor to provide acceptable harmonic performance at full load, where harmonic performance is most critical.

h. The VFD’s full load amp rating shall meet or exceed NEC Table 430-150. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 160% of rated current for up to 0.5 second while starting.

i. The VFD shall be able to provide full torque at any selected frequency from 29 Hz to base speed to allow driving direct drive fans without derating.

j. An automatic energy optimization selection feature shall be provided standard in the VFD. This feature shall automatically and continually monitor the motor’s speed and load and adjust the applied voltage to maximize energy savings and provide up to an additional 3% to 10% energy savings.

k. Input and output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD. Switching rate may be up to 1 time per minute on the input and unlimited on the output.

l. An automatic motor adaptation test algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to run the test.

m. Galvanic and/or optical isolation shall be provided between the VFD’s power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analog I/O and discrete I/O shall include additional isolation modules.
n. VFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD efficiencies while reducing motor noise.

o. VFD supplier shall coordinate with motor supplier to ensure that all motors 20 horsepower and greater are provided with grounding bushings.

(4) Protective Features

a. A minimum of Class 20 $I^2t$ electronic motor overload protection for single motor applications and thermal-mechanical overloads for multiple motor applications shall be provided.

b. Protection against input transients, loss of AC line phase, output short circuit, output ground fault, overvoltage, undervoltage, VFD overtemperature and motor overtemperature. The VFD shall display all faults in plain English. Codes are not acceptable.

c. Protect VFD from sustained power or phase loss. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD will continue to operate with reduced output with an input voltage as low as 164 V AC for 208/230 volt units, 313 V AC for 460 volt units, and 394 volts for 600 volts units.

d. The VFD shall incorporate a motor preheat circuit to keep the motor warm and prevent condensation build up in the stator.

e. VFD package shall include semi-conductor rated input fuses to protect power components.

f. To prevent breakdown of the motor winding insulation, the VFD shall be designed to comply with IEC Part 34-17. Otherwise the VFD manufacturer must ensure that inverter rated motors are supplied.

g. VFD shall include a “signal loss detection” circuit to sense the loss of an analog input signal such as 4 to 20 mA or 2 to 10 V DC, and shall be programmable to react as desired in such an instance.

h. VFD shall function normally when the keypad is removed while the VFD is running and continue to follow remote commands. No warnings or alarms shall be issued as a result of removing the keypad.

i. VFD shall catch a rotating motor operating forward or reverse up to full speed.

j. VFD shall be rated for 100,000 amp interrupting capacity (AIC).

k. VFD shall include current sensors on all three output phases to detect and report phase loss to the motor. The VFD will identify which of the output phases is low or lost.
l. VFD shall continue to operate without faulting until input voltage reaches 300 V AC on 208/230 volt units, 539 V AC on 460 volt units, and 690 volts on 600 volt units.

(5) Interface Features

a. Hand/Start, Off/Stop and Auto/Start selector switches shall be provided to start and stop the VFD and determine the speed reference.

b. The VFD shall be able to be programmed to provide a 24 V DC output signal to indicate that the VFD is in Auto/Remote mode.

c. The VFD shall provide digital manual speed control. Potentiometers are not acceptable.

d. Lockable, alphanumeric backlit display keypad can be remotely mounted up to 10 feet away using standard 9-pin cable.

e. The keypads for all sizes of VFDs shall be identical and interchangeable.

f. To set up multiple VFDs, it shall be possible to upload all setup parameters to the VFD’s keypad, place that keypad on all other VFDs in turn and download the setup parameters to each VFD. To facilitate setting up VFDs of various sizes, it shall be possible to download from the keypad only size independent parameters.

g. Display shall be programmable to display in 9 languages including English, Spanish and French.

h. The display shall have four lines, with a minimum of 20 characters on three lines and a minimum of eight large characters on one line.

i. A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.

j. A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD eliminating the need for macros.

k. As a minimum, the following points shall be controlled and/or accessible:

1) VFD Start/Stop
2) Speed reference
3) Fault diagnostics
4) Meter points
   (a) Motor power in HP
   (b) Motor power in kW
   (c) Motor kW-hr
   (d) Motor current
   (e) Motor voltage
   (f) Hours run
   (g) Feedback signal #1
(h) Feedback signal #2
(i) DC link voltage
(j) Thermal load on motor
(k) Thermal load on VFD
(l) Heatsink temperature

1. Four additional Form C 230 volt programmable relays shall be available for factory or field installation within the VFD.

m. Two set-point control interface (PID control) shall be standard in the unit. VFD shall be able to look at two feedback signals, compare with two set-points and make various process control decisions.

n. Floating point control interface shall be provided to increase/decrease speed in response to contact closures.

o. Four simultaneous displays shall be available. They shall include frequency or speed, run time, output amps and output power. VFDs unable to show these four displays simultaneously shall provide panel meters.

p. Sleep mode shall be provided to automatically stop the VFD when its speed drops below set “sleep” level for a specified time. The VFD shall automatically restart when the speed command exceeds the set “wake” level.

q. The sleep mode shall be functional in both follower mode and PID mode.

r. Run permissive circuit shall be provided to accept a “system ready” signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of sending an output signal as a start command to actuate external equipment before allowing the VFD to start.

s. The following displays shall be accessible from the control panel in actual units: Reference Signal Value in actual units, Output Frequency in Hz or percent, Output Amps, Motor HP, Motor kW, kWhr, Output Voltage, DC Bus Voltage, VFD Temperature in degrees, and Motor Speed in engineering units per application (in GPM, CFM, etc.). VFD will read out the selected engineering unit either in a linear, square or cubed relationship to output frequency as appropriate to the unit chosen.

t. The display shall be programmed to read in inches of water column (in-wg) for an air handler application, pressure per square inch (psi) for a pump application, and temperature (°F) for a cooling tower application.

u. VFD shall be able to be programmed to sense the loss of load and signal a no load/broken belt warning or fault.

v. If the temperature of the VFD’s heat sink rises to 80°C, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. If the temperature of the heat sink continues to rise the VFD shall automatically reduce its output frequency to the motor. As the VFD’s heat sink temperature returns to normal, the VFD shall automatically increase
the output frequency to the motor and return the carrier frequency to its normal switching speed.

w. The VFD shall have temperature controlled cooling fans for quiet operation and minimized losses.

x. The VFD shall store in memory the last 10 faults and related operational data.

y. Eight programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.

z. Two programmable relay outputs, one Form C 240 V AC, one Form A 30 V AC, shall be provided for remote indication of VFD status.

aa. Three programmable analog inputs shall be provided and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include two voltage (0 to 10 V DC, 2 to 10 V DC) and one current (0 to 20 mA, 4 to 20 mA) input.

bb. Two programmable 0 to 20 mA analog outputs shall be provided for indication of VFD status. These outputs shall be programmable for output speed, frequency, current and power. They shall also be programmable to provide a selected 24 V DC status indication.

c. Under fire mode conditions, the VFD shall be able to be programmed to automatically default to a preset speed.

d. On motors connected to variable frequency drives, 20hp or greater in size. Provide grounding bushings to prevent arching.

(6) Interface With Building Automation System/Direct Digital Control System

a. VFD manufacturer shall provide an interface to the BAS/DDC system. Manufacturer shall coordinate as required with the Controls Contractor. Provide Bacnet, Lonworks, FLN, Modbus, or any other interface required for a complete and operational system.

b. Provide mode of operation to BAS/DDC system (hand, off, auto, etc.). BAS/DDC graphic shall highlight or produce pop-up graphic when VFD is in hand or off. Also, provide all points to BAS/DDC identified in section (4).K of this Specification.

(7) Adjustments

a. VFD shall have an adjustable carrier frequency in steps of not less than 0.1 kHz to allow tuning the VFD to the motor.

b. Sixteen preset speeds shall be provided.

c. Four acceleration and four deceleration ramps shall be provided. Accel and decel time shall be adjustable over the range from 0 to 3,600 seconds to base speed. The shape of these curves shall be automatically contoured to ensure no-trip acceleration and deceleration.
d. Four current limit settings shall be provided.

e. If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: undervoltage, overvoltage, current limit and inverter overload.

f. The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds.

g. An automatic “on delay” may be selected from 0 to 120 seconds.

(8) Service Conditions

a. Ambient temperature, -10 to 40°C (14 to 104°F), without derating.

b. 0 to 95% relative humidity, non-condensing.

c. Elevation to 3,300 feet without derating.

d. AC line voltage variation, -10 to +10% of nominal with full output.

e. No side clearance shall be required for cooling of any units. All power and control wiring shall be done from the bottom.

(9) Quality Assurance

a. To ensure quality and minimize infantile failures at the jobsite, the complete VFD shall be tested by the manufacturer. The VFD shall operate a dynamometer at full load and speed and shall be cycled during the test.

b. All optional features shall be functionally tested at the factory for proper operation.

(10) Submittals

a. Submit manufacturer’s performance data including dimensional drawings, power circuit diagrams, installation and maintenance manuals, warranty description, VFD’s FLA rating, certification agency file numbers and catalog information.

The specification lists the minimum VFD performance requirements for this project. Each supplier shall list any exceptions to the specification. If no departures from the specification are identified, the supplier shall be bound by the specification.

a. Harmonic filtering. The seller shall, with the aid of the buyer’s electrical power single line diagram, providing the data required by IEEE-519, perform an analysis to initially demonstrate the supplied equipment will met the IEEE standards after installation. If, as a result of the analysis, it is determined that additional filter equipment is required to meet the IEEE recommendations, then the cost of such equipment shall be included in the bid. A harmonic analysis shall be submitted with the approval drawings to verify compliance with the latest version of IEEE-519 voltage and current distortion limits as shown in table 10.2.
and 10.3 at the point of common coupling (PCC). The PCC shall be defined as the consumer–utility interface or primary side of the main distribution transformer.

(11) **Start-Up Service**

a. The manufacturer shall provide on-site start-up commissioning of the VFD and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. Sales personnel and other agents who are not factory certified shall not be acceptable as commissioning agents. Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the building automation system. Provide start-up report to Engineer.

(12) **Warranty**

a. The VFD shall be warranted by the manufacturer for a period of 36 months from date of shipment. The warranty shall include parts, labor, travel costs and living expenses incurred by the manufacturer to provide factory authorized on-site service. The warranty shall be provided by the VFD manufacturer.

(13) **Examination**

a. Contractor to verify that job site conditions for installation meet factory recommended and code-required conditions for VFD installation prior to start-up, including clearance spacing, temperature, contamination, dust, and moisture of the environment. Separate conduit installation of the motor wiring, power wiring, and control wiring, and installation per the manufacturer’s recommendations shall be verified.

b. The VFD is to be covered and protected from installation dust and contamination until the environment is cleaned and ready for operation. The VFD shall not be operated while the unit is covered.

G. **HYDRONIC SPECIALTIES**

(1) **Manufacturers**

Subject to compliance with the specified and scheduled requirements the following manufacturers will be considered, but not limited to:

- Hoffman
- Amtrol/Thrush
- Armstrong/Aurora
- Bell & Gossett
- Patterson
- Taco
- Victaulic
- Wheatley
(2) **Air Release Tank**

The air release tank shall be of the in-the-pipe-line type with flanged tangential openings for inlet and outlet connections. The inside shall be specifically designed to create a low velocity vortex for the separation of free air from the water stream. The tank shell shall be rated at 125 PSI working pressure and shall be constructed with the ASME code for unfired pressure vessels and shall be so certified and stamped. The tank shall be equipped with a bottom drain connection and expansion tank/vent connection. Tank shall be line sized. Tank shall not have a strainer.

(3) **Expansion Tank**

The tank shall be constructed in accordance with the ASME Code for unfired pressure vessels and shall be suitable for 125 PSI water working pressure and 340°F maximum water temperature. The tank shall be a pre-charged, heavy duty butyl rubber diaphragm-type pressure vessel complete with standard tire charging valve. Refer to the plans for mounting orientation. Capacities shall be as scheduled on the drawings.

(4) **Factory-Assembled Drops**

Contractor has the option to utilize pump drop assemblies in lieu of traditional method consisting of flexible connectors and flanged components. Pump Drops shall consist of orange enamel coated assembly, consisting of a Class 150 flange for pump connection, Standard of Acceptance: Victaulic Series 380/381/385/26.

Suction Vibration Isolation Pump Drop: Factory assembled grooved end vibration pump suction drop for pipe sizes 3” through 12”. Consisting of a suction diffuser with stainless steel basket and diffuser, Vic-300 butterfly valve with offset stem for 360-degree circumferential seating, and pipe spool with thermometer and or pressure ports. Assembly is installation-ready, with flexible couplings to accommodate vibration attenuation and stress relief. Assembly rated for working pressure to 300-psig.

Discharge Vibration Isolation Pump Drop: Factory assembled grooved end vibration pump discharge drop for pipe sizes 3” through 12”. Consisting of tri-service valve assembly, which includes a 779 spring-actuated check valve and Vic-300 butterfly valve with offset stem for 360-degree circumferential seating, and pipe spool with thermometer and pressure ports. Assembly is installation ready, with flexible couplings to accommodate vibration attenuation and stress relief. Assembly rated for working pressure is 300-psig.

(5) **Suction Diffusers**

Provide at the inlet of each base mounted pump, a suction diffuser as manufactured by Bell and Gossett, Victaulic, Thrush, or approved equivalent. Each suction diffuser shall be equipped with a disposable fine mesh start-up strainer and an adjustable support foot to carry weight of inlet piping. Victaulic Series 731 G, W731G, Bell and Gossett Suction Diffuser, or equal.

(6) **Flexible Connections**
Provide at the inlet and discharge side of each base mounted pump, at each connection to major equipment requiring vibration isolation and where shown on plans, a flexible connector, Metaflex Metrasphere or Engineer approved equal. Flexible connectors shall be of the flexible neoprene and nylon or EPDM and suitable for 225 PSI working pressure and 230°F temperature. Couplings shall be installed per the manufacturer's recommendations, in close proximity to the source of the vibration.

Alternatively, in lieu of a flexible connector, three (3) Victaulic Style 77 flexible couplings may be used on suction side and discharge side of base mounted pumps (six Victaulic flexible couplings per pump).

(7) **Pressure Reducing Valve**

Provide at the point of connection of the domestic water line to the hydronic system and where shown on the plans, a pressure reducing valve by Thrush, Bell and Gossett, or Engineer approved equivalent. Such pressure reducing shall be provided with an inlet strainer and shall be set to maintain a pressure of 4 PSI in excess of that at the highest point in the hydronic system. Each pressure reducing valves shall be line sized.

(8) **Vacuum Breaker**

Provide, where shown on the plans, a vacuum breaker as manufactured by Huffman, Jackson or Engineer approved equivalent.

(9) **Manual Air Vents**

Provide, where shown on the plans, at each rise in piping and where required a manual air vent.

(10) **Automatic Air Vents**

Provide, where shown on the plans, automatic air vents.

(11) **Expansion Loops**

Expansion loops shall be Metaflex Metra loops or Engineer approved equivalent. Install with pipe guides and anchors as recommended by the manufacturer in all piping runs 75 feet long or greater and also where indicated on the plans.

Alternatively, in water piping systems, use adequate numbers of Victaulic Style 77 flexible couplings in header piping to accommodate thermal growth and contraction, and as required for the elimination of expansion loops. (In accordance with Victaulic recommendations and as approved by the Engineer). Where expansion loops are required in Victaulic piping systems, use Victaulic flexible couplings on the loop(s).

2. **FACTORY START-UP REPORTS**
A. Provide factory start-up on site by a factory representative (not a third party contractor) for all HVAC equipment, including pumps, VFD’s, boilers, heat pumps, etc. Submit factory start-up reports to the Engineer. The Mechanical Contractor and the Controls Contractor shall have a representative on site to correct all deficiencies noted by the factory representative. For each deficiency noted, documentation of corrective action taken shall be submitted to Engineer.

B. At a minimum, the report submitted to the Engineer shall include the following data:

(1) Outside Air Units/Energy Recovery Units
   a. Fan rotation
   b. Recovery wheel rotation
   c. Confirm all wiring connections are correct
   d. Confirm all field wiring is correct
   e. Adjust belt tensions and alignments
   f. Confirm pipe connections are correct
   g. Confirm sequence of operation is correct
   h. Confirm damper operation

(2) Boiler
   a. Control circuit Component Operational Test is required.
      Test the following:
      1) Primary LWCO
      2) Secondary LWCO
      3) High Pressure gas switch (if gas fired boiler)
      4) Low Pressure gas switch (if gas fired boiler)
      5) High Limit Setting
      6) Operating Control Setting
      7) Oil pressure switch (if oil fired boiler)
      8) Air Flow Switch
      9) Firing rate control
      10) Low fire start switch
      11) High fire purge switch
   b. Running Motor Amps and Volts vs. Nameplate amps and volts.
   c. Measuring the following and verify measurements within manufacturer’s recommendations:
      1) Firing Rate
      2) CO2
      3) O2
      4) Smoke or CO
      5) Stack Temperature Net ºF
      6) Room Temperature
      7) Over fire draft (in. W.C.)
      8) Breeching Draft (in. W.C.)
9) Inlet/Outlet Water Temp °F/Steam outlet pressure
10) Air inlet shutter % Open
11) Flame Signal Pilot
12) Flame Signal Main
13) Oil pressure/Gas pressure
14) Bypass oil pressure
15) Atomizing Air Pressure
16) Combustion Efficiency

(3) Ventilating/Exhaust Fans
   a. Fan rotation direction
   b. Motor current draw

(4) Air Handling Units/MAU
   a. Verify economizer operation
   b. Verify operating per sequence of control
   c. Discharge air temperature sensor calibration
   d. Discharge static pressure
   e. Dirty filter differential pressure switch function
   f. Outside air temperature sensors calibration
   g. Return air temperature sensor calibration
   h. Airflow monitoring station calibration
   i. VFD response to pressure sensors or other DDC input
   j. Smoke detection shut down
   k. Freeze protection sequence
   l. Fan bearings lubrication
   m. Fan not vibrating
   n. Fan motor volts / amps
   o. Check drive belt tension
   p. Check sheave alignment
   q. Coils clean
   r. Dampers operating properly
   s. Filters clean
   t. Fan rotation direction

(5) Split DX Systems
   a. Compressor operation
   b. Condenser fan operation
   c. Refrigerant flow system
   d. Indoor air handler
   e. Condensate removal
   f. Properly set on equipment pad

(6) Heat Pump Systems
   a. Compressor operation
3. WATER TREATMENT

A. SCOPE

Provide a one-year water treatment program for the HCS and HPS water loop systems. The one-year period shall start from the date of substantial completion. The program shall minimize corrosion, scaling, and prevent biological fouling of the piping system.

B. QUALIFICATIONS

Chemicals, service, and equipment shall be supplied by a single water treatment company for undivided responsibility. The water treatment chemical and service supplier shall be a recognized specialist, active in the field of commercial/industrial water treatment for at least 5 years, whose major business is in the field of industrial water treatment. The water treatment company shall have regional water analysis laboratories, service department, and full time representatives located within the trading area of the job site or facility.

Water treatment company shall be Bluegrass Kesco, Nalco, American Water Treatment, or approved equal.

C. SERVICE

Provide quarterly field service and Owner consultation. System water or fluid shall be tested for proper chemical parameters, clarity, and biological activity. If needed, provide chemical addition. Provide any laboratory and technical assistance required to achieve a successful program.

D. CHEMICALS

Provide one year’s supply of the recommended chemical for scale and corrosion protection of the closed loop recirculating system. If needed, provide separate chemical to control microbiological growth in the system. Formulations shall not contain any ingredients which are harmful to system materials of construction.

E. EQUIPMENT

(1) Bypass Feeder
Provide one 5 gallon bypass chemical feeder for each system. Neptune DBF-5HP or approved equivalent.

(2) **HPS Loop Filter LF-1**

Harmsco HIF or WB series fluid filter. Refer to schedule on the drawings for selection. Provide with a total of three sets of filter cartridges.

**F. REPORTS**

A summary of water or fluid quality and treatment shall be provided in writing to the Owner and Engineer after each quarterly site visit. Results of quarterly biological activity tests shall also be provided to the Owner and Engineer.

**4. HEATING SYSTEM CLEANING**

Should be used for radiant and hot water system.

**A. GENERAL**

The heating/cooling system for this contract is a hydronic heat pump system and there are several precautions which must be observed during its installation. The Contractor is advised to read all of the manufacturer's instructions prior to commencing the installation.

**B. SYSTEM START-UP**

The Contractor shall include as a part of his work a factory system fill and start-up by an authorized Factory Representative of the unit manufacturer.

**C. CLEANING AND FLUSHING HYDRONIC HEATING PIPING SYSTEMS**

(1) During construction, extreme care shall be exercised to prevent all dirt and other foreign matter from entering the pipe or other parts of the system. Pipe stored on the project shall have the open ends capped and equipment shall have all openings fully protected. Before erection, each piece of pipe, fitting or valve shall be visually examined and all dirt removed.

(2) After the system is complete it shall be thoroughly cleaned before placing in operation to rid the system of dirt, biological contamination, piping compound, loose mill scale, oil and any and all other material foreign to the water.

(3) Before chemical cleaning and sterilization of the entire system, the loop field shall be flushed and purged until free of dirt, debris, and air. During the chemical cleaning and sterilization process the supply and return run-outs shall be temporarily connected together at each heat pump location.
(4) After purging of the field loop the Contractor shall add an approved system cleaning solution at the recommended concentration to the entire system. Circulate the system with cleaner for the time recommended by the chemical manufacturer. After prescribed circulation time, flush the system until cleaner is removed.

(5) After chemical cleaning, the entire system shall be sterilized. Introduce a solution of sodium hypochlorite to achieve a chlorine residual of 25 to 50 ppm. Maintain this chlorine level for 12 to 24 hours. Flush out system until chlorine residual in system equals that of the makeup water.

(6) After the system has been completely cleaned and sterilized as specified herein, the individual heat pumps shall be connected permanently to the supply and return runouts and the system filled for operation under normal closed loop conditions. Within 48 hours of the completion of the sterilization implement a water treatment program to passivate all metal surfaces.

5. HVAC SYSTEM START-UP PROCEDURE

A. GENERAL

(1) The goal of this procedure is for a few units to run as much as possible with the coils as cold as possible to "wring out" the water and allow it to drain away in the condensate drain pans. Allowing all units to cycle on and off, running for short periods of time, does not dehumidify the air in the building. Starting the system without following the steps outlined will raise the relative humidity in the building and most likely cause condensation on some of the building surfaces and HVAC system that the Contractor will be responsible to correct.

(2) The high humidity and condensation occurs in school buildings at start up primarily because the building is only partly occupied (or not occupied) when the HVAC system is started. Most people believe that the answer to this problem is to turn the thermostats down very low. The assumption is that cold air will not hold moisture. That is not true. What happens is that the thermostats are quickly satisfied thermally because there is very little cooling load on the building and the cooling equipment. The terminal units then only have to run for a very short period of time to keep the thermostats satisfied and the relative humidity of the air is in fact raising. The goal is to cause the moist air to pass over coils which are cooling it and drying it without allowing more moist air to be introduced into the building.

(3) To reduce the always present high humidity start-up problem, we have devised this start-up procedure that will minimize the adverse effects of the start-up. As the building sits at start-up, all of the walls, floor, and ceilings are saturated with moisture from the air and also moisture is being released from the drying paint and curing concrete and mortar.

(4) The following procedure will slowly bring down the temperature and humidity in the lightly loaded building. It will also allow the HVAC equipment to more closely match the actual building load without students and equipment in use.

To reach these goals we require the following:
(1) Set 1/3 of the units (approximately every third unit) on 74°F (no lower). Set the other thermostats for a cooling setpoint of 90°F so the units will not cool. Override the controls so that the fans in all units will circulate air.

(2) Leave all of the interior doors open to allow the air to mix throughout the building.

(3) Close all exterior windows and doors.

(4) Turn off all exhaust fans and outside air units. Outside air unit exhaust and outside air dampers shall be closed.

(5) Leave all of the lights on in the building to provide a cooling load.

(6) Provide portable electric heaters or dehumidifiers in any room that shows signs of condensation.

Here is a list of things you should not do:

(1) Do not prop the exterior doors open during construction or while moving in furnishings.

(2) Do not start all of the units until students are starting school. When students start school the normal setpoints, schedules, and fan cycling shall begin.

END OF SECTION 15700
SECTION 15720 - CONDENSATE DRAINAGE SYSTEM (FOR COOLING EQUIPMENT)

1. GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, General Conditions-Mechanical and to all other Contract Documents as they apply to this section of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.

B. The Contractor shall provide a complete condensate drainage system to carry all condensate discharge from all cooling equipment from the building. Condensate system shall be installed in accordance with IMC. Provide condensate overflow switch for all condensate producing equipment.

C. Pipe installation and fabrication shall be in accordance with the section of these specifications entitled PIPE, PIPE FITTINGS AND PIPE SUPPORT and as hereinafter specified.

D. All piping shall be installed concealed, unless specifically noted otherwise and shall be installed under slabs or underground only when specifically indicated.

E. Lines installed in ceiling spaces shall be held at the maximum possible elevation and shall be coordinated with all other trades to avoid conflicts.

F. Condensate drain lines shall be pitched 1/4 inch per foot and installed with cleanout plugs at each change in direction and/or at thirty (30) foot intervals. Where this minimum pitch cannot be attained, contact Engineers.

G. Horizontal runs of condensate drain lines shall be supported at six (6) foot intervals maximum, or more frequently where required to prevent sags and low spots.

H. Lengths of horizontal lines shall be held at a minimum due to potential lint collection.

I. Provide condensate traps in accordance with the manufacturer’s recommendations.

2. MATERIAL

A. Refer to Section of these Specifications entitled: PIPE, PIPE FITTINGS AND SUPPORT.

3. INSULATION

A. Refer to Section of these Specifications entitled: INSULATION - MECHANICAL.

END OF SECTION 15720
SECTION 15810 - SHEET METAL AND FLEXIBLE DUCT

1. GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, General Requirements-Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified herein.

B. This branch of the work includes all materials, labor and accessories for the fabrication and installation of all sheet metal work as shown on the drawings and/or as specified herein. Where construction methods for various items are not indicated on the drawings or specified herein, all such work shall be fabricated and installed in accordance with the recommended methods outlined in the latest edition of SMACNA's HVAC Duct Construction Standards, Metal and Flexible, and its subsequent addenda. HVAC duct systems shall be fabricated and installed in accordance with the SMACNA duct construction standards (SMACNA-HVAC and SMACNA-Seismic) including Appendix B of the Seismic Restraint Manual Guidelines for Mechanical Systems. These references and plate numbers shall be used by the Engineer for required sheet metal thicknesses and final acceptance of methods of fabrication, hanging, accessories, etc. All equipment furnished by manufacturers shall be installed in strict accord with their recommended methods.

C. Ductwork shall be constructed and installed per the latest edition of the International Mechanical Code.

D. Ductwork shall be kept clean at all times. Ductwork stored on the job site shall be placed a minimum of 4” above the floor and shall be completely covered in plastic. Installed ductwork shall be protected with plastic to prohibit dust and dirt from entering the installed ductwork, air handling unit, terminal devices, etc. Provide temporary filters on all return grilles and duct openings if the units are running prior to the building being satisfactorily cleaned. Do not install the ductwork if the building is not “dried-in”. If this is required, the open ends of duct shall be covered in plastic to protect. The Owner/Engineer shall periodically inspect that these procedures are followed. If deemed unacceptable, the Contractor shall be required to clean the duct system utilizing a NADCA certified Contractor.

Prior to purchase and fabrication of ductwork (shop fabricated or manufactured), the Contractor shall coordinate installations with new and existing conditions. Notify the Engineer if there are any discrepancies for resolution.

E. Provide a SMACNA duct cleanliness level “C” per the latest SMACNA standards. [Refer to LEED / Healthcare Requirements]

F. If separate filter grilles are specified for an HVAC unit the Contractors shall remove any unit mounted filters and blank off the unused filter access opening with sheet metal and seal air tight.

G. Wall Penetrations: Where ducts penetrate interior or exterior walls, the walls shall be sealed air tight. Refer to the sleeving, cutting, patching, and repairing section of the specifications for additional requirements.
H. Duct dimensions indicated are required inside clear dimensions. Plan duct layouts for adequate insulation and fitting clearance.

I. Prior to purchase/shipment of the ductwork, manufacturer shall provide as part of the submittal process scaled, field coordinated Autocad drawings of the complete system to be furnished. Drawings will indicate all system components including fittings, ductwork and manifolds. Drawings shall be available in an electronic format.

2. LOW PRESSURE DUCTWORK

A. General (Low Pressure)

(1) Double turning vanes shall be installed in all square turns and in any other locations indicated.

(2) Provide a “high efficiency” type take-off with round damper (Flexmaster STOD-B03 or approved equal) for all round duct branches from a rectangular main to a GRD. Refer to the detail on the drawings for all installation requirements.

(3) Cross-break all ducts where any duct section dimension or length is 18” or larger.

(4) Air volume dampers shall be installed in each duct branch takeoffs and/or where indicated, whichever is more stringent. All such dampers shall be accessible without damage to finishes or insulation and shall be provided where required for proper system balance.

(5) Splitter dampers shall be provided in all rectangular supply air duct tees. Damper blade operator shall extend a minimum two inches thru the insulation.

(6) Unless otherwise dimensioned on the drawings, all diffusers, registers and grilles shall be located aesthetically and symmetrically with respect to lighting, ceiling patterns, doors, masonry bond, etc. Locate all supply, return and exhaust diffusers and grilles in the locations shown on the architectural reflected ceiling plan.

(7) Ducts shall be hung by angles, rods, 18 ga. minimum straps, trapezes, etc., in accordance with SMACNA’s recommended practices. Duct supports shall not exceed 12 ft intervals. There shall be no less than one set of hangers for each section of ductwork. Where ductwork contains filter sections, coils, fans or other equipment or items, such equipment or items shall be hung independently of ductwork with rods or angles. Do not suspend ducts from perlins or other weak structural members where no additional weight may be applied. If in doubt, consult the structural engineer.

(8) Provide approved flexible connectors at inlet and outlet of each item of heating and cooling equipment whether indicated or not. Install so as to facilitate removal of equipment as well as for vibration and noise control.

(9) All ductwork connections, fittings, joints, etc., including longitudinal and transverse joints, seams and connections shall be sealed. Seal with medium pressure, smooth-textured, water based duct sealant. Sealant shall be UL 181B-M listed, UL 723 classified, NFPA 90A & 90B compliant.
permanently flexible, nonflammable, and rated to 15” wg. Apply per manufacturer's recommendations. Contractors shall insure no exposed sharp edges or burrs on ductwork.

(10) All angular turns shall be made with the radius of the center line of the duct equivalent to 1.5 times the width of the duct.

(11) Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA and/or as indicated. Test openings shall be placed at the inlet and discharge of all centrifugal fans, coils, VAV boxes, fan sections of air handling units, at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.

(12) Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated walls. Fire stop rating shall meet or exceed the rating of the wall. Provide an approved access panel at each fire damper located and sized so as to allow hand reset of each fire dampers. All such fire dampers and access panels shall be readily accessible without damage to finishes. Refer to Architectural Plans for locations of fire rated walls. All access doors shall be 16”x16” or as high as ductwork permits and 16” in length.

(13) The Contractor who installs the sheet metal shall furnish to the Air Balancing Contractor, a qualified person to assist in testing and balancing the system.

(14) All fans and other vibrating equipment shall be suspended by independent vibration isolators.

(15) The interior surface of the ductwork connecting to return/exhaust air grilles shall be painted flat black. The ductwork shall be painted a minimum of 24” starting from the grille.

B. Materials (Low Pressure Single Wall)

(1) Ductwork, plenums and other appurtenances shall be constructed of the following:


b. Exposed ductwork in finished spaces requiring insulation such as gymnasiums, etc., shall be dual wall ductwork.

(2) Ductwork, plenums and other appurtenances shall be constructed of the materials of the minimum weights or gauges as required by the latest SMACNA 2” W.G. Standard or the below table, whichever is more stringent. When gauge thickness differs, the heavier gauge shall be selected. The below table shall serve as a minimum:
C. Materials (Low Pressure Double Wall Ductwork)

(1) Install Double Wall Ductwork in the following areas:

   a. Anywhere supply ductwork is installed exposed to view in spaces (other than mechanical rooms)
   b. At all other locations indicated on drawings.

(2) Furnish and install where indicated double wall duct. The double wall duct shall be Eastern Sheet Metal, United McGill, Semco or approved equivalent. The duct shall have an inner shell, a 1-inch layer of fiberglass insulation and an outer pressure shell.

(3) Ductwork outer shell shall be spiral, lock-seam construction fabricated from galvanized steel meeting ASTM-527 standard. Any ductwork exposed to view shall be constructed of G90 galvanized steel, 20 gauge, and shall be supported as required with aircraft cables and self-tightening locks. Ductwork shall be constructed as specified in LOW PRESSURE DUCTWORK.

(4) Inner shell for spiral pipe shall be a perforated inner liner. The inner liner shall have 3/32" perforation with an overall open area of 23%.

(5) Inner shell for spiral pipe shall be solid galvanized steel and constructed of the minimum guage specified with 3 intermediate reinforcing ribs.

(6) Inner shell for fittings shall be galvanized steel. All fittings shall be manufactured by the same manufacturer as the spiral pipe. Fittings shall be constructed a minimum of 22 Ga.

(7) The fiberglass liner shall have a maximum thermal conductivity (k) factor of 0.27 btu per hour per square foot per degree Fahrenheit per inch thickness at 75 degree F ambient temperature.

### ROUND DUCT VS RECTANGULAR DUCT

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(8) All double wall ductwork will be furnished with factory installed flanges equal to Eastern Sheet Metal Flange which shall consist of a 1.5 outer flange and an inner secondary flange which shall keep the inner flange concentric and eliminate inner wall connections. Flanges requiring inner couplings will not be allowed, no insulation shall be exposed to the airstream at the connections.

(9) All grille and register taps shall be factory manifolded. Field installed taps will not be allowed. Manifolded taps may be tack welded and caulked for appearance. Only taps for grilles and registers may be provided this way. All other fittings shall be full body welded.

D. Miscellaneous (Low Pressure)

(1) Un-insulated Flexible ductwork (Use Only Where Indicated)
   a. Un-insulated flexible ductwork shall be corrugated aluminum. No sections shall be greater than five feet in length. Ductwork shall be UL rated and in accordance with IMC.
   b. Flexible ductwork installed in a return or exhaust or other negative static pressure application shall be rated for installation in negative pressure systems.

(2) Insulated Flexible Duct (Use Only Where Indicated)
   a. Owens/Corning or equivalent, 1 ½” inch thick fiberglass insulation; flexible liner; with aluminum pigment vinyl vapor barrier facing. Insulated flexible duct shall meet Fire Hazards Standards of NFPA 90A and IMC, flame spread not to exceed 25, smoke develop and fuel contributed not to exceed 50 when tested in accordance with ASTM E84. Minimum R-value of 6.0, tested in accordance with ASTM C177.71. Flexible duct may be used only for runouts and no sections shall be more than five feet in length.
   b. When flexible duct is located in areas where it will be visible because the ceiling allows views to the ductwork above, the flexible duct shall be black. The black color shall be factory coloring and not field applied.
   c. Flexible duct shall not be used in areas where there is no ceiling.
   d. Flexible ductwork installed in a return or exhaust or other negative static pressure application shall be rated for installation in negative pressure systems.

(3) Flexible Connectors: Duro-Dyne, Ventfabrics, Inc., U.S. Rubber or equivalent; conforming to NFPA Pamphlet No. 90-A; neoprene coated glass fabric; 20 oz. for low pressure ducts secured with snap lock.

(4) Turning Vanes: Duro-Dyne or equivalent fabricated as recommended by SMACNA: noiseless when in place without mounting projections in ducts. All turning vanes shall be double blade type.

(5) Splitter Damper: Splitter damper shall be constructed of 16 gauge galvanized steel. Provide with operating hardware by Ventfabrics, Inc. to include damper blade bracket, ball joint bracket and operator shaft. Operator shall extend two inches from duct to allow for external insulation, where
required. Regulator shall seal operator shaft air tight. Install hardware as recommended by manufacturer.

(6) Access Doors; In Ductwork: Flexmaster TBSM, Air Balance, Vent Products or equal. Access doors for rectangular ducts shall be 16"x16" where possible. Otherwise install as large an access door as height permits by 16" in length. Door shall be 1” thick double-wall insulated with continuous hinge and cam lock. Provide in ducts where indicated or where required for servicing equipment whether indicated or not. Provide a hinged access door in duct adjacent to all fire, smoke and control dampers for the purpose of determining position. Access doors shall also be provided on each side of duct coils (water, electric, steam, etc.) and downstream side of VAV boxes and CAV boxes.

(7) Architectural Access Doors In Ceilings or Walls: Provide where required to access equipment, dampers, valves, filters, etc. Provide Kees D Panel, Cesco, Milcor or equal. Panels shall be 24”x24” in size and constructed with 16 gauge galvannealed steel for door and frame. In finished areas, provide with primed steel with 1” border to accept architectural specified finish. In Mechanical, Electrical, or service spaces, provide brushed satin finish with 1” border. Door shall include three (3) screwdriver operated cam latches and concealed continuous pivoting rod hinge. Door shall open 175 degrees. For masonry construction, furnish frames with adjustable metal masonry anchors. For fire rated units, provide manufacturer’s standard insulated flush panel/doors with continuous piano hinge and self-closing mechanism. The Contractor shall include all required access doors in the bid and shall coordinate with the General Contractor prior to the bid to insure a complete project.

(8) Security Architectural Access Doors in Walls: Provide where required to access equipment, dampers, valves, filters, etc. Provide Kees SSAP Panel, Cesco, Milcor or equal. Panels shall be 24”x24” in size and constructed with 12 gauge steel for door and frame. In finished areas, provide with primed steel with 1” border to accept architectural specified finish. In Mechanical, Electrical, or service spaces, provide brushed satin finish with 1” border. Door shall include key-operated cylinder dead bolt lock (coordinate cylinders and keys with Owner to match facility standards) and concealed continuous pivoting rod hinge. Door shall open 175 degrees. For masonry construction, furnish frames with adjustable metal masonry anchors and straps. For fire rated units, provide manufacturer’s standard insulated flush panel/doors with continuous piano hinge and self-closing mechanism. The Contractor shall include all required access doors in the bid and shall coordinate with the General Contractor prior to the bid to insure a complete project.

(9) Volume Dampers (Rectangular): Ruskin, Model MD35 or Empco, Air Balance; Louvers and Dampers, Titus, Carnes, Cesco/Advanced Air, Creative Metals, United Air, Pottorf rectangular volume dampers. Frames shall be 4” x 1 "x 16 gauge galvanized steel. Blades shall be opposed blade 16 gauge galvanized steel with triple crimped blades on 6” centers. Linkage shall be concealed in jamb. Bearings shall be ½” nylon. Maximum single section size shall be 48” wide and 72” high. Provide with Ventfabrics 2” high elevated dial regulator to avoid damper handle from conflicting with duct insulation. Provide permanent mark on dial regulator to mark air balance point.

(10) Volume Dampers (Round): Ruskin, Model MDRS25 or, Empco, Air Balance; Louvers and Dampers, Titus, Carnes, Cesco/Advanced Air, Creative Metals, United Air, Pottorf round volume
dampers. Dampers shall be butterfly type consisting of circular blade mounted to axle. Frames shall be 20 gauge steel, 6" long. Damper blades shall be 20 gauge galvanized steel. Axle shall be 3/8"x6" square plated steel. Bearing shall be 3/8" nylon. Provide with Ventfabs 2" high elevated dial regulator to avoid damper handle from conflicting with duct insulation. Provide permanent mark on dial regulator to mark air balance point.

(11) Fire Dampers: Fire dampers shall comply with IMC and shall be constructed and tested in accordance with UL Safety Standard 555. Each fire damper shall have a 1-1/2 or 3 hour fire protection rating as required by fire wall. Damper shall have a 165ºF fusible link, and shall include a UL label in accordance with established UL labeling procedures. Fire damper shall be equipped for vertical or horizontal installation as required by the location shown. Fire dampers shall be installed in wall and floor openings utilizing 16 gauge minimum steel sleeves, angles, other materials, practices required to provide an installation equipment to that utilized by the manufacturer when dampers were tested at UL. Installation shall be in accordance with the damper manufacturer's instructions. All fire dampers shall be dynamic. Static fire dampers are not allowed. Provide velocity level and pressure level as required for application (if in doubt, contact Engineer). Fire dampers shall be Ruskin Type DIBD for 1-1/2 hour rating or Ruskin Type DIBD 23 for a 3 hour rating. Other acceptable manufacturers are Air Balance, Prefco, Greenheck, Nailor, or Safe Air. Provide an access door for fire damper reset at all fire damper locations.

(12) Motor Driven Smoke Dampers – Air Foil Blade: Provide Ruskin SD60 smoke damper where required by the locations of smoke partitions or as shown on the plans, whichever is more stringent. Other acceptable manufacturers are Air Balance or Pottorff. All smoke dampers shall be three inches larger than HVAC duct in each direction. Frame shall be a minimum of 18 gauge galvanized steel formed into a structural hat channel shaper with tabbed corners for reinforcement. The blade shall be airfoil shaped, constructed of a dual skinned galvanized steel, 14 gauge equivalent thickness, on 6" maximum centers. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. Jamb seal shall be stainless steel flexible metal compression type. Each smoke damper shall be classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to same. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (to open and close under HVAC system operating conditions) with pressures of at least the maximum possible of the HVAC system in the closed position, and the system maximum duct air velocity in the open position. In addition to the leakage ratings already specified herein, the dampers and their actuators shall be qualified under UL555S to an elevated temperature of 350 degrees F. Appropriate electric actuators shall be installed by the damper manufacturer. Refer to building fire alarm and controls for exact type. Actuator to be mounted outside of air stream. The pressure drop shall not be greater than .16’ wg @ 2500 FPM when tested by an independent laboratory. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements.

(13) Motor Driven Fire/Smoke Dampers – Air Foil Blade: Fire damper shall be constructed and tested in accordance with UL Safety Standard 555. The damper shall be Ruskin FSD60. Other acceptable manufacturers are Air Balance or Pottorff. The blade shall be airfoil shaped, constructed of a dual skinned galvanized steel, 14 gauge equivalent thickness, on 6" maximum centers. Frame is to be a minimum of 16 gauge galvanized steel, rollformed into a structural hat shape channel. Frame seals shall consist of flexible, compression type stainless steel. The damper
and actuator electric shall be rated to an elevated temperature or 250 degrees F or 350 degrees F. In addition the damper must be factory supplied with actuator and sleeve to comply with the requirements of UL 555S. These dampers shall have been constructed and tested in compliance with U.L. Standard 555 and U.L. Standard 555S, current editions. The pressure drop shall not be greater than .25 in.wg. At 2500 fpm when tested by an independent laboratory. Each damper shall bear an approved U.L. label identifying its classification as a Dynamic Rated fire Damper (Static Rated dampers are not acceptable), and shall further be classified by U.L. as a Leakage Rated Damper for use in Smoke Control Systems. Each damper shall have a 1-1/2 hour fire protection rating, 212EF U.L. Listed fusible link and a leakage class I. In addition to the leakage ratings already specified herein, the dampers and their actuators shall be qualified under UL555S to an elevated temperature of 350 degrees F. Appropriate electric actuators shall be installed by the damper manufacturer. Refer to building fire alarm and controls for exact type. Provide factory supplied caulked sleeve, 20 gauge on dampers through 84” wide and 18 gauge above 84” wide. Actuator to be mounted outside of air stream. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements.

(14) Motor Driven control Dampers – Provide Ruskin Model CD50 air foil damper as shown on the plans. Frame shall be a minimum of 16 gauge galvanized steel formed into a structural hat channel shaper with tabbed corners for reinforcement. The blade shall be airfoil shaped, constructed of a dual skinned galvanized steel, 14 gauge equivalent thickness, 6 inches wide. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. Jamb seal shall be stainless steel flexible metal compression type. Blade seals shall be equal to Ruskinprene. Leakage Rating shall be Pressure/Class 1.

3. MEDIUM PRESSURE DUCTWORK

A. General (Medium Pressure)

(1) All ductwork connections, fittings, joints, etc., shall be sealed. Seal with high velocity, smooth-textured, water based duct sealant. Sealant shall be UL 181B-M listed, UL 723 classified, NFPA 90A & 90B compliant, permanently flexible, non-flammable, and rated to 15”wg. Apply per manufacturer’s recommendations.

(2) Ductwork shall be installed per SMACNA Medium or High Pressure Manual, whichever is applicable. (Latest Edition shall apply.)

(3) All hanger straps shall be 18 ga. minimum with reinforcement angles installed in strict accordance with SMACNA. Flat oval ducts shall be installed with 2”x2”x1/4” angles on top and bottom ducts 18” wide and larger. Use 1”x1”x3/16” angles on ducts under 18” wide.

(4) Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA or the duct manufacturer, and/or as indicated. Test openings shall be placed at the discharge of all air handling units and at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.
(5) Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated walls. Fire stop rating shall meet or exceed the rating of the wall. Provide an approved access panel at each fire damper located and sized so as to allow hand reset of each fire damper. All such fire dampers and access panels shall be readily accessible without damage to finishes. Refer to Architectural Plans for locations of fire rated walls. Where access doors are installed in insulated ductwork, the access door shall be the insulated type.

B. Materials (Medium Pressure Single Wall)

(1) All round, rectangular, and oval medium pressure ductwork for systems above 1.5” W.G. shall be Eastern Sheet Metal, United McGill or Semco or equal with construction as required by the latest SMACNA Standard (Refer to required pressure rating of the duct system as outlined in the Duct Schedule of this spec section).

(2) Any ductwork exposed to view shall be double wall and constructed of galvanized steel. Galvanized metal shall be prepped and clean prior to painting. Coordinate with General Contractor.

Ductwork shall be spiral, lock-seam construction fabricated from galvanized steel meeting ASTM-527 standard. Ductwork shall be constructed of materials of the minimum weights or gauges as required by the latest SMACNA Standard (Refer to required pressure rating of the duct system as outlined in the Duct Schedule of this spec section) or the below table. When gauge thickness differs, the heavier gauge shall be selected. The below table shall serve as a minimum:

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<td>52 TO 60</td>
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<td>85 AND ABOVE</td>
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(3) All high velocity duct fittings shall be fabricated by the same manufacturer as the spiral pipe. Contractor or field fabricated fittings shall not be accepted. Duct fittings shall be constructed per the latest SMACNA standard (Refer to required pressure rating of the duct system as outlined in the Duct Schedule of this spec section) with continuous welds. Take-off fittings shall be combination type tees (Eastern Sheet Metal Model “CB” or equal). Straight or angle tees are not acceptable. Fittings shall be constructed of the following minimum gauges:
ROUND DUCT (or Equivalent Round Diameter for Oval Ducts)  

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<td>61 TO 84</td>
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(4) All single wall ductwork will be furnished with factory installed flanges equal to Eastern Sheet Metal Flange on all ductwork greater than 24 inches in size.

C. Materials (Medium pressure Double Wall)

(1) Furnish and install where indicated by drawings or specifications medium pressure double wall duct. The double wall duct shall be United McGill Acoustic K27, SEMCO, Dixie or approved equivalent. The duct shall have a solid galvanized steel inner liner, an intermediate layer of fiberglass insulation minimum 1” thick and an outer pressure shell. Duct shall be of spiral lockseam construction fabricated from galvanized steel meeting ASTM-A527 standard. The duct insulation shall have minimum R-value of 6.0. Medium pressure double wall fittings shall have the same construction features as the double wall duct. Duct shall be constructed of G90 Galvanized steel. Outer shell of ductwork shall be constructed of the minimum gauges specified above for single wall medium pressure ductwork.

(2) All double wall ductwork will be furnished with factory installed flanges equal to Eastern Sheet Metal Flange which shall consist of a 1.5 outer flange and an inner secondary flange which shall keep the inner flange concentric and eliminate inner wall connections. Flanges requiring inner couplings will not be allowed, no insulation shall be exposed to the airstream at the connections.

D. Miscellaneous (Medium pressure)

(1) Flexible Connectors: Duro-Dyne, Ventfabrics, U.S. Rubber or equivalent; conforming to NFPA Pamphlet No. 90-A or IMC, whichever is more stringent; neoprene coated glass fabric; 30 oz. for medium pressure ducts secured with bolted angles. Provide flexible connectors at inlet and outlet of air handling equipment to accommodate a minimum of three times the operating pressure of the system.

(2) Architectural Access Doors In Ceilings or Walls: Provide where required to access equipment, dampers, valves, filters, etc. Provide Kees D Panel, Cesco, Milcor or equal. Panels shall be 24”x24” in size and constructed with 16 gauge galvannealed steel for door and frame. In finished areas, provide with primed steel with 1” border to accept architectural specified finish.
Mechanical, Electrical, or service spaces, provide brushed satin finish with 1" border. Door shall include three (3) screwdriver operated cam latches and concealed continuous pivoting rod hinge. Door shall open 175 degrees. For masonry construction, furnish frames with adjustable metal masonry anchors. For fire rated units, provide manufacturer’s standard insulated flush panel/doors with continuous piano hinge and self-closing mechanism. The Contractor shall include all required access doors in the bid and shall coordinate with the General Contractor prior to the bid to insure a complete project.

(3) Security Architectural Access Doors in Walls: Provide where required to access equipment, dampers, valves, filters, etc. Provide Kees SSAP Panel, Cesco, Milcor or equal. Panels shall be 24"x24" in size and constructed with 12 gauge steel for door and frame. In finished areas, provide with primed steel with 1” border to accept architectural specified finish. In Mechanical, Electrical, or service spaces, provide brushed satin finish with 1” border. Door shall include key-operated cylinder dead bolt lock (coordinate cylinders and keys with Owner to match facility standards) and concealed continuous pivoting rod hinge. Door shall open 175 degrees. For masonry construction, furnish frames with adjustable metal masonry anchors and straps. For fire rated units, provide manufacturer’s standard insulated flush panel/doors with continuous piano hinge and self-closing mechanism. The Contractor shall include all required access doors in the bid and shall coordinate with the General Contractor prior to the bid to insure a complete project.

(4) Fire Dampers: Fire dampers shall comply with IMC and shall be constructed and tested in accordance with UL Safety Standard 555. Each fire damper shall have a 1-1/2 or 3 hour fire protection rating as required by fire wall. Damper shall have a 165°F fusible link, and shall include a UL label in accordance with established UL labeling procedures. Fire damper shall be equipped for vertical or horizontal installation as required by the location shown. Fire dampers shall be installed in wall and floor openings utilizing 16 gauge minimum steel sleeves, angles, other materials, practices required to provide an installation equipment to that utilized by the manufacturer when dampers were tested at UL. Installation shall be in accordance with the damper manufacturer’s instructions. All fire dampers shall be dynamic. Static fire dampers are not allowed. Provide velocity level and pressure level as required for application (if in doubt, contact Engineer). Fire dampers shall be Ruskin Type DIBD for 1-1/2 hour rating or Ruskin Type DIBD 23 for a 3 hour rating. Other acceptable manufacturers are Air Balance, Prefco, Greenheck, Nailor, or Safe Air. Provide an access door for fire damper reset at all fire damper locations.

(5) Motor Driven Smoke Dampers – Air Foil Blade: Provide Ruskin SD60 smoke damper where required by the locations of smoke partitions or as shown on the plans, whichever is more stringent. Other acceptable manufacturers are Air Balance or Pottorff. Frame shall be a minimum of 18 gauge galvanized steel formed into a structural hat channel shaper with tabbed corners for reinforcement. The blade shall be airfoil shaped, constructed of a dual skinned galvanized steel, 14 gauge equivalent thickness, on 6” maximum centers. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. Jamb seal shall be stainless steel flexible metal compression type. Each smoke damper shall be classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to same. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (to open and close under HVAC system operating conditions) with pressures of at least the maximum possible of the HVAC system in the closed position, and the system maximum duct air velocity in the open position. In addition to the leakage ratings
already specified herein, the dampers and their actuators shall be qualified under UL555S to an elevated temperature of 350 degrees F. Appropriate electric actuators shall be installed by the damper manufacturer. Refer to building fire alarm and controls for exact type. Actuator to be mounted outside of air stream. The pressure drop shall not be greater than .16" wg @ 2500 FPM when tested by an independent laboratory. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements.

(6) Motor Driven Fire/Smoke Dampers – Air Foil Blade: Fire damper shall be constructed and tested in accordance with UL Safety Standard 555. The damper shall be Ruskin FSD60. Other acceptable manufacturers are Air Balance or Pottorff. The blade shall be airfoil shaped, constructed of a dual skinned galvanized steel, 14 gauge equivalent thickness, on 6" maximum centers. Frame is to be a minimum of 16 gauge galvanized steel, rollformed into a structural hat shape channel. Frame seals shall consist of flexible, compression type stainless steel. The damper and actuator electric shall be rated to an elevated temperature or 250 degrees F or 350 degrees F. In addition the damper must be factory supplied with actuator and sleeve to comply with the requirements of UL 555S. These dampers shall have been constructed and tested in compliance with U.L. Standard 555 and U.L. Standard 555S, current editions. The pressure drop shall not be greater than .25 in.wg. At 2500 fpm when tested by an independent laboratory. Each damper shall bear an approved U.L. label identifying its classification as a Dynamic Rated fire Damper (Static Rated dampers are not acceptable), and shall further be classified by U.L. as a Leakage Rated Damper for use in Smoke Control Systems. Each damper shall have a 1-1/2 hour fire protection rating, 212EF U.L. Listed fusible link and a leakage class I. In addition to the leakage ratings already specified herein, the dampers and their actuators shall be qualified under UL555S to an elevated temperature of 350 degrees F. Appropriate electric actuators shall be installed by the damper manufacturer. Refer to building fire alarm and controls for exact type. Provide factory supplied caulked sleeve, 20 gauge on dampers through 84" wide and 18 gauge above 84" wide. Actuator to be mounted outside of air stream. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements.

(7) Motor Driven control Dampers – Provide Ruskin Model CD60 air foil damper as shown on the plans. Frame shall be a minimum of 16 gauge galvanized steel formed into a structural hat channel shaper with tabbed corners for reinforcement. The blade shall be airfoil shaped, constructed of a dual skinned galvanized steel, 14 gauge equivalent thickness, 6 inches wide. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. Jamb seal shall be stainless steel flexible metal compression type. Blade seals shall be equal to Ruskinprene. Leakage Rating shall be Pressure/Class 1.

(8) Access Doors; In Rectangular Medium Pressure Ductwork: Flexmaster TBSM, Air Balance, Vent Products or equal. Access doors for rectangular ducts shall be 16”x16” where possible. Otherwise install as large an access door as height permits by 16” in length. Door shall be 1” thick double-wall insulated with continuous hinge and cam lock. Provide in ducts where indicated or where required for servicing equipment whether indicated or not. Provide a hinged access door in duct adjacent to all fire, smoke and control dampers for the purpose of determining position.

(9) Access Doors; In Round or Oval Medium Pressure Ductwork: All access doors in round or oval medium pressure ductwork shall be screw and gasketed type. Screws shall be maximum 4 inches on centers. Access door sizes shall be as follows:
(10) Pressure Relief Doors: Provide a pressure relief vent in the supply air ductwork at each air handling unit. It shall be located between the fan outlet and the first manual or automatic (i.e., fire, fire smoke, or any motorized) damper or closure device. It shall be sized to relieve the duct air pressure below the rated pressure construction of the ductwork and above the working pressure of the fan. The supply air relief door shall be Ruskin PRD18 or equal. Provide a vacuum relief vent in the return and/or outside air ductwork at each air handling unit. It shall be located between the air handling unit casing and the first manual or automatic damper or closure device. It shall be sized to relieve the duct vacuum below the rated construction of the ductwork and above the working negative pressure of the fan. The return air relief door shall be Ruskin NRD18 or equal. Automatic fan shutdown upon damper closure shall not be an acceptable protection for either overpressure or vacuum conditions. All duct pressure relief doors shall be of the automatic resetting type unless otherwise noted.

4. TYPE 1 KITCHEN RANGE HOOD EXHAUST DUCT

A. Ducts shall be constructed of 18 gauge stainless steel with liquid tight continuous external weld of all seams and joints where exposed. Where ducts are concealed, they shall be constructed of 16 gauge black steel with liquid-tight continuous weld of all seams and joints. Inside laps on duct joints shall project in a direction against the air flow.

B. Ducts shall be so constructed and sloped as to provide suitable drainage of grease to a collection point or to hood. At the base of each vertical riser or low point in ductwork, a residue trap shall be provided with provisions for cleanout per IMC. Ducts shall slope a minimum of 1⁄4” per foot. Horizontal ducts exceeding 75 ft in length must slope a minimum of 1” per foot.

C. Hand holes for inspection and cleaning purposes, equipped with tight fitting sliding or swinging doors and latches, shall be provided in horizontal and vertical sections of exhaust ducts. Such openings shall be at the sides of the horizontal run in order to prevent dripping of residue. Spacing of such openings shall not exceed 20 feet and shall be located at all offsets and grease collection points. Openings shall have a minimum dimension of 20” in width with a height equivalent to the duct height minus one inch.

D. No turning vanes or dampers shall be installed in type 1 grease duct.

E. The Contractor shall install the kitchen rangehood exhaust duct systems and maintain the minimum code required clearances to combustibles. The use of UL listed and approved enclosure system of fire wraps/blankets installed per the manufacturer’s instructions are acceptable when required to achieve the clearance to combustibles requirements.
F. At the Contractor’s option and where noted on the plans, a UL2221 Pre-manufactured Duct System equal to Metal Fab 3G shall be acceptable. Duct shall have a stainless steel inner liner, aluminized outer liner and one or three inch liner as required to comply with requirements of clearance to combustibles.

G. Shop drawings of the kitchen rangehood exhaust ductwork shall be made and submitted to the appropriate reviewing agency. Any fees associated with this submittal shall be borne by this Contractor.

5. DRYER VENT

A. All dryer ducting shall be a minimum of 4” in diameter. Refer to the drawings for exact duct sizing.

B. Dryer vent ductwork shall be rigid metal 20-gauge aluminum duct. Duct joints shall be installed so that the male end of the duct points in the direction of the airflow. Joints shall be secured with metal tape (not duct tape). Do not use rivets or screws in the joints or anywhere else in the duct as these will incur lint collection.

C. Length of concealed rigid metal ducting shall not exceed the allowable length of 35 feet. Deduct 5 feet from the allowable length for every 4” 90 degree elbow and 4” 2.5 feet for every 45 degree fitting. Lengths may vary per local codes and dryer manufacturer’s recommendations. Install per 2012 IMC Section 504 Clothes Dryer Exhaust. Provide a complete, working in-line booster fan system, including power, if the maximum allowable duct length is exceeded.

D. Flexible transition hose connection at the dryer shall be the aluminum flexible duct type. Do not use the plastic or vinyl.

E. Termination of dryer venting shall be to the exterior with a proper hood or roof jack equipped with a backdraft damper. Hood/jack shall be painted with suitable exterior grade paint and color per the Owner’s direction. Small orifice metal screening shall not be part of the hood or roof jack as this will trap lint and block the opening. The hood opening shall point down and maintain a minimum of 12 inches of clearance between the bottom of the hood and the ground or other obstruction.

6. WATER HEATER AND BOILER FLUE STACKS

A. Location

(1) All flues shall be offset to provide, whether indicated or not, a minimum of 10’ horizontal separation to any air intake. This distance shall be a 25’ minimum on healthcare facilities.

B. Natural Draft, Gas-Fired Water Heaters and Boilers (Maximum Flue Temperature 300°F., Maximum Size 8 Inches Diameter)

(1) Metal Fab Type M, or approved equivalent Type “B” gas vent system. Gas Vent shall be double wall construction, with inner wall constructed of aluminum and outer wall constructed of...
galvanized steel. Gas vent system shall be UL listed and installed in strict accordance with the manufacturers recommendations. Provide with factory fittings such as elbows, tees, increasers, draft hood connections, tall cone flashing, storm collar, wall thimble, metal cap, etc., as required for a complete project. Minimum UL listed clearance to combustibles shall be one inch.

C. Natural Draft, Gas-Fired Water Heaters and Boilers (Maximum Flue Temperature 400°F; 10 Inch Diameter and Greater In Size)

(1) Metal Fab Type M, or approved equivalent Type "B" gas vent system. Gas vent shall be double wall construction. Inner wall shall be aluminum and outer wall galvanized steel. One-half inch insulating air space shall be provided between the walls. Gas vent system shall be UL listed and installed in strict accordance with the manufacturer's recommendations. Provide with factory fittings such as elbows, tees, tee cap, cap, tall cone flashing, support plate increaser etc., as required for a complete project. Shop drawings shall be submitted for Engineer's review. Minimum UL listed clearance to combustibles shall be one inch.

D. Gas-Fired Water Heaters and Boilers With Barometric Damper or Number 2 Fuel Oil-Fired Water Heaters and Boilers (Maximum Flue Temperature 1000°F)

(1) AMPCO Model "NPS" or approved equivalent double wall negative pressure system. Vent shall be double wall construction. Inner wall shall be Type 304 stainless steel. Outer wall shall be aluminum coated steel. One inch insulating air space shall be provided between walls. Minimum UL listed clearance to combustibles shall be twelve inches. Provide vent spaces as required. Vent system shall be UL listed in strict accordance with the manufacturer's recommendations. Provide with factory fittings such as elbows, tees, tee cap, cap, tall cone flashing, support plate, increaser, etc., as required for a complete project. Shop drawings shall be submitted for Engineer's review.

E. Positive Pressure vent systems for Water Heaters and Boilers, Gas-Fired or Oil-Fired (Maximum Flue Temperature 1000°F)

(1) Metal Fan PIC or approved equivalent double wall positive pressure system. Vent shall be double wall construction. Inner wall shall be 20 gauge, Type 304 stainless steel. Outer wall shall be 24 gauge aluminum coated steel. One inch insulating air space shall be provided between walls. Minimum UL listed clearance to combustibles shall be ten inches. Provide vent spaces as required. Vent system shall be UL listed in strict accordance with the manufacturer's recommendations. Provide with factory fittings such as elbows, tees, tee cap, cap, tall cone flashing, support plate, increaser, etc., as required for a complete project. Shop drawings shall be submitted for Engineer's review.

F. Category II and Category IV Appliances (Positive and Negative Pressure Condensing Appliances)

(1) Metal-Fab Corr/Guard, Heat-Fab Saf-T Vent or other approved equal meeting the specification below:
The vent shall be of the double wall, factory-built type for use on condensing appliances or pressurized venting systems serving Category II, III, or IV appliances or as specified by the equipment manufacturer.

Maximum temperature shall not exceed 550°F.

Vent shall be listed for an internal static pressure of 6” w.g. and tested to 15” w.g.

Vent shall be constructed on an inner and outer wall with a 1” annular insulating air space.

The inner wall (vent) shall be constructed of AL29-4C superferritic stainless steel, .015 thickness for 6”-12” diameters and .024 thickness for 14”-24” diameters.

The outer wall (casing) shall be constructed of type 304 stainless steel. .018 thickness for 6”-12” diameters and .024 thickness for 14”-24” diameters.

Inner and outer walls shall be connected by means of spacer clips that maintain the concentricity of the annular space and allow unobstructed differential thermal expansion of the inner and outer walls.

Product shall carry the appropriate UL listing mark or label.

6” to 12” diameter vent shall have 1” clearance to combustibles at 550°F. 14” to 24” diameter vent shall have 5” clearance to combustibles at 550°F.

7. FLUE CAPS

A. Provide a flue cap on all flues. It shall be similar to the Breident positive downdraft eliminator style.

8. DUCT SCHEDULE

A. Supply Ducts:

(1) Ducts Connected to Heat Pumps and Makeup Air unit
   a. Pressure Class: Positive 2-inch wg Refer to Low Pressure requirements as outlined in section 2 of this spec.
   b. Minimum SMACNA Seal Class: C.
   c. SMACNA Leakage Class for Rectangular: 24.
   d. SMACNA Leakage Class for Round and Flat Oval: 12.

B. Return Ducts:

(1) Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps and Makeup Air unit
   a. Pressure Class: Negative 2-inch wg Refer to Low Pressure requirements as outlined in section 2 of this spec.
   b. Minimum SMACNA Seal Class: C.
   c. SMACNA Leakage Class for Rectangular: 24.
C. Exhaust/Relief Ducts:

(1) Ducts Connected to Exhaust Fans

   a. Pressure Class: Negative 2 inch wg Refer to Low Pressure requirements as outlined in section 2 of this spec
   b. Minimum SMACNA Seal Class: [C]
   c. SMACNA Leakage Class for Rectangular: [24]
   d. SMACNA Leakage Class for Round and Flat Oval: [12]

(2) Ducts Connected to Air-Handling Units OA-1

   a. Pressure Class: Negative 2 inch wg Refer to Low Pressure requirements as outlined in section 2 of this spec
   b. Minimum SMACNA Seal Class: [C]
   c. SMACNA Leakage Class for Rectangular: [24]
   d. SMACNA Leakage Class for Round and Flat Oval: [12]

D. Outdoor Air Ducts:

(1) Ducts Connected to Heat Pumps and OA-1

   a. Pressure Class: Positive 2-inch wg Refer to Low Pressure requirements as outlined in section 2 of this spec.
   b. Minimum SMACNA Seal Class: C.
   c. SMACNA Leakage Class for Rectangular: 24.
   d. SMACNA Leakage Class for Round and Flat Oval: 12.

12. Air Leakage Testing of the Ductwork Systems

   A. It is the intent of this section to ensure the ductwork installed has minimal air leakage.

   B. Air leakage testing shall be accomplished by an AABC or NEBB certified company. Refer to the Test & Balance specifications.

   C. It is the intent to test all ductwork. The duct systems which will require testing are as follows:

      (1) All supply air duct systems
      (2) All return air duct systems.
      (3) All exhaust air duct systems.
(4) All make-up air duct systems.

D. Do not insulate the supply air systems prior to testing.

E. The maximum allowable air leakage rate for each system tested must conform to SMACNA required leakage class rating as specified in section 11, DUCT SCHEDULE, of this spec.

F. All return and exhaust air sheet metal ductwork associated with the system shall be tested. Flexible ductwork shall not be tested. Cap the main duct prior to the central equipment fan connection. Also cap the branch ducts which serve the diffusers, after the round branch air volume with sheet metal caps. Seal caps well to damper to avoid air loss at this location. This air loss, from the caps, is included in the noted leakage rate.

G. The noted allowable leakage rate is the total allowable. It shall include leakage associated with the following:

   (1) All ductwork as described in above paragraphs.

   (2) Access doors

   (3) Volume dampers

   (4) Relief air doors

   (5) Smoke dampers

   (6) Fire dampers

   (7) Fire smoke dampers

   (8) End caps used to seal ducts

H. If any duct system fails a test, the contractor shall reseal the system. It shall then be retested until the duct system meets the leakage allowance at no additional cost to the owner.

I. Carefully select the ductwork construction requirements and the type of duct sealant to be used as required to meet the leakage allowances. The sheet metal duct pressure classification is a minimum only. The contractor shall select the appropriate sheet metal pressure classification, duct sealant class and duct sealant materials to meet the project air leakage allowances.

J. A duct pre-installation conference shall be held prior to the installation of the ductwork. Present should be the owner’s representative, engineer, Test & Balance Contractor, General Contractor, Mechanical Contractor, Sheet Metal Contractor, Insulation Contractor and the manufacturer’s representative of the duct sealant to be used. At this meeting, the contractor shall advise all of the duct materials and sealant materials to be used to meet the air leakage allowances.
K. Whenever the systems are being leak tested by the Test & Balance Contractor, a representative from the Mechanical Contractor shall be present to assist.
SECTION 15850 - REGISTERS, GRILLES, DIFFUSERS & LOUVERS

1. REGISTERS, GRILLES AND DIFFUSERS

   A. GENERAL

       Alternate R, G & D selections, other than manufacturers and models listed below, will be accepted, provided quality, function and characteristics are equivalent. Acceptable alternates are Price, Titus, Metalaire, Carnes, Anemostat, Kruegar, and Tuttle & Bailey. Shop drawings shall identify and list all characteristics of each device exactly as scheduled herein. Finishes shall be selected by the Architect. If Architect elects not to select color, all colors shall be off-white. Factory color samples shall be submitted with shop drawings.

   B. SELECTION

       Refer to the Selections Scheduled on the Drawings.

2. DIFFUSERS FOR RAISED FLOOR AND ACCESSIBLE FLOOR SYSTEMS

   A. Provide floor mounted supply diffusers as required to distribute supply air CFM of air handling equipment scheduled to serve raised/accessible floor areas. Coordinate placement of diffusers in the room with manufacturer of equipment to be set in the room. Diffusers shall be manufactured specifically for raised floor applications and shall support foot traffic and equipment. At the Contractor’s option, diffusers may be supplied by the accessible floor system manufacturer; it is emphasized, however, that the Contractor is finally responsible for providing a finished air distribution system for the raised/accessible floor system.

3. LOUVERS

   A. GENERAL

       Alternate louver selections, other than manufacturer and model listed below, will be accepted, provided quality, function and characteristics are equivalent. Acceptable alternates are Ruskin, Air Balance, Airline, Airstream, Louvers and Dampers and Penn. Shop drawings shall identify and list all characteristics of each device exactly as scheduled herein. Finishes shall be selected by the Architect unless scheduled otherwise.

   B. LINTELS

       Provide lintels above all louvers as required. Refer to the lintel schedule in Specification Section 201100.

   C. SELECTION

       Refer to the Selections Scheduled on the Drawings.
END OF SECTION 15850
SECTION 15900 - CONTROLS – DIRECT DIGITAL

1. GENERAL

ALTERNATE #1 – OWNER PREFERED ALTERNATE FOR HARSHAW TRANE BUILDING CONTROL SYSTEM.

A. The Contractor shall furnish all labor, materials, equipment and services required to provide a complete temperature control system as specified and as shown on the plans.

B. Prior to the installation of or payment for any work, the Contractor shall prepare submittals which shall be reviewed by the Architect and Engineer. These submittals shall include a complete control diagram and sequence of operation of the entire system, plus engineering data on all devices used.

C. The Contractor shall be a licensed installer of HVAC temperature controls by a national temperature controls manufacturer. Acceptable manufacturers are Trane, Siemens, Johnson, Honeywell, Andover, TAC, Invensys, Alerton or Automated Logic. The installer shall have 5 years experience and installed a minimum of 8 systems of similar size. Their offices shall be within 150 miles of the project site.

D. The system herein specified shall be free from defects in workmanship and material under normal use and service if, within twelve (12) months from the date of acceptance by the Engineer, any of the equipment herein described is proved to be defective in workmanship or material, it will be adjusted, repaired, or replaced free of charge by the Contractor.

E. All equipment, unless specified to the contrary, shall be fully proportioning and adjustable. The Control System shall consist of all room thermostats, air stream thermostats, valves, damper operators, relays, freeze protection equipment, dampers, panels, and other accessory equipment not provided with the equipment to fill the intent of the specifications and drawings.

F. Complete freeze protection equipment shall be provided at all required locations. Freeze protection thermostats shall have twenty foot elements and be capable of de-energizing the circuit when any point along the element reaches the set point of the thermostat. Freezestat elements shall be placed on the leaving side of each heating coil, so that every square foot on the heating coil is protected. On heating coils larger than eighteen (18) square feet, provide multiple freezestats wired in series. The Contractor shall insure that all freeze protection devices and equipment has been fully tested prior to the heating season and shall so certify in writing to the Engineers. The cost of replacement of equipment damaged by freeze-up caused by improper freeze protection or faulty control equipment shall be borne by the Contractor.

G. All units, controls, equipment, heat pumps, etc., and controls shall reset automatically when power is restored after an outage.

H. All control wiring concealed in walls and exposed in mechanical rooms, closets, etc., shall be in conduit. Provide plenum rated wiring where cable is concealed above ceilings. Do not paint
wiring. The Contractor is responsible for protecting wiring from paint. Any painted cabling shall be replaced.

I. All dampers shall be capable of operating properly with the system pressures encountered. This shall include modulating and shut-off functions.

J. The Contractor shall also refer to the mechanical maintenance, HVAC equipment, and all other sections of the specifications for additional control requirements.

K. Provide smoke detectors and shut down control for all air handling units and combined air systems as required by the KBC and IMC Section 606.

L. All DDC controllers or control modules shall have covers to protect the circuit boards. All wiring shall be anchored securely within 6" of the controller.

M. Provide all control dampers, etc. not supplied with the equipment or required to accomplish the sequences specified.

N. The Contractor shall provide all refrigeration control and interlock wiring as recommended by the equipment manufacturer.

O. Wiring and required conduit in connection with the control system(s), including power wiring of any voltage, shall be installed by the Contractor. The Contractor may, at his option, engage the Electrical Contractor to accomplish this work. It is emphasized however, that the Contractor is finally responsible for all such work.

P. Electric power for the control panels, modules, unit controller, damper motors, etc., shall be derived from the building electric system. Power shall not be derived from the HVAC equipment power source or equipment low voltage transformers (internal or integral).

Q. The electrical work required for the installation of the control system(s), shall be provided by the Contractor in accordance with all National and Local Electrical Codes. All wiring shall be concealed except in Mechanical Rooms. All electrical work specified under this division of the specifications shall also comply with Division 16 of these specifications.

R. All exterior electrical work, equipment, etc. shall be waterproofed.

S. Controls system and all related components shall comply with ASHRAE Standard 135 (BACnet protocol).

2. OWNER’S TRAINING

A. The Contractor shall provide full instructions to designated personnel in the operation, maintenance, and programming of the system. The training shall be specifically oriented to the system and interfacing equipment installed. Four hours of Owner Training shall be provided at substantial completion, again after 6 months and again 1 year after substantial completion. The
Owner Training shall include an overview of the entire HVAC system operation, temperature sensor setpoint manipulation, critical alarm training and graphics display overview. Subcontractors shall be present during Owner training sessions.

B. The Contractor shall provide a Sign-in Sheet and Meeting Minutes of the training. The Contractor shall also video record the initial training sessions. Complete Operations and Maintenance Manuals shall be reviewed by the Contractor during training.

3. CONTROL SYSTEM CHECKOUT AND TESTING – BY CONTROLS CONTRACTOR PRIOR TO DEMONSTRATION AND ACCEPTANCE

A. Startup Testing. Complete startup testing to verify operational control system before notifying Owner of system demonstration. Provide Owner with schedule for startup testing. Owner may have representative present during any of all startup testing.

(1) Calibrate and prepare for service each instrument, control, and accessory equipment furnished under Section 250200.
(2) Verify that control wiring is properly connected and free of shorts and ground faults.
(3) Enable control systems and verify each input device’s calibration. Calibrate each device according to manufacturer’s recommendations.
(4) Verify that binary output devices such as relays, solenoid valves, two-position actuators and control valves, and magnetic starters, operate properly and that normal positions are correct.
(5) Verify that analog output devices such as I/Ps and actuators are functional, that start and span are correct, and that direction and normal positions are correct. Check control valves and automatic dampers to ensure proper action and closure. Make necessary adjustments to valve stem and damper blade travel.
(6) Prepare a log documenting startup testing of each input and output device, with technician’s initials certifying each device has been tested and calibrated. Submit log to Engineer for review.
(7) Verify that system operates according to sequences of operation. Simulate and observe each operational mode by overriding and varying inputs and schedules. Tune PID loops and each control routine that requires tuning.
(8) Alarms and Interlocks.
   a. Check each alarm with an appropriate signal at a value that will trip the alarm.
   b. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction.
   c. Test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.

4. EQUIPMENT

A. CONTROL PANEL(S)

(1) Each system shall be provided with a local panel for mounting of all relays, switches, controllers, and thermometers associated with that system. Where one cabinet will not accommodate all the equipment necessary for one system, a second cabinet shall be mounted.
and bolted adjacent to it. Cabinets shall be provided with a 2/3's door. All devices shall be provided with lamacoid plastic nameplates for identification.

B. THERMOSTATS

(1) General

a. All thermostats shall have a "warmer-cooler" knob. This control shall allow the space occupants to reset the temperature up or down a predetermined amount. This amount, or no amount at all, shall be settable thru the BAS.

b. The thermostat shall have an unoccupied override button and an integral communications port.

c. The thermostat shall have no integral thermometer.

d. All thermostats provided for the project shall be similar in size and appearance.

e. Provide tamper-proof guards for all wall mounted thermostats selected by Owner.

f. All thermostats shall be mounted on a plastic base or other insulating material to prevent wall coupling effect.

g. Thermostats shall be mounted with the top at a maximum of 48" A.F.F. and shall be mounted to comply with A.D.A.

h. Thermostats shall provide temperature deadband of 5˚ F as required by IECC 2012.

i. Backboxes in rated walls shall be a minimum of 24” from any other back box to maintain the wall rating.

C. DAMPERS

(1) Several louvers of practical widths shall be provided for larger dampers. Modulating dampers shall have opposed blades. Dampers shall have edge and end seals. Dampers shall be Ruskin CD-60 or better. Maximum leakage rate shall be 2 CFM per square foot at 1" W.G. pressure differential for dampers greater than 12" wide. Leak rate for dampers 12" and less shall be 3 CFM per square foot. NOTE: Do not mount outside air dampers so close to water coils, piping, etc., that freeze-up may occur due to a leaky damper.

D. RELAYS AND SWITCHES

(1) Relays and switches shall be of the positive and gradual acting type and shall be furnished and installed as required for the successful operation of the system. All switches shall have suitable indicating plates.
E. VALVES

(1) All valves shall be of the fully modulating and silent type unless otherwise specified. They shall provide accurate control of the heating or cooling medium under all load conditions. All valves 2-inches or smaller shall have brass or bronze bodies with screwed ends. Valves 2-1/2 inches and larger shall have iron bodies, brass or bronze trimming with flange ends. Valves shall be normally open or normally closed as required. Valves shall be installed with the stem in the upright position or as recommended by the valve manufacturer.

5. DEMONSTRATION

A. A complete demonstration and readout of the capabilities of the monitoring and control system shall be performed. The contractor shall demonstrate on-site with the Owner and Engineer that all points and sequences operate as designed.

The warranty does not start until all controls, graphics, points, etc. are functioning.

All controls functioning on _____________________________ Date

Witnessed by ___________________________________________

6. SEQUENCE OF CONTROL

A. Refer to Controls Drawings

END OF SECTION 15900
SECTION 15910 - MOTOR STARTERS AND OTHER ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT

1. MOTOR STARTERS-GENERAL

   A. Where motor starters are required for mechanical equipment they are to be the responsibility of the Contractor furnishing the equipment as outlined herein.

   B. Motor starters shall be furnished by the Equipment Supplier with his equipment. Coordinate all requirements for starters with equipment suppliers and other trades.

   C. Motor starters shall be NEMA style. I.E.C.-style starters are not to be provided. Their sizing and installation shall be coordinated with the equipment manufacturer's requirements and in accordance with the National Electrical Code.

   D. Unless otherwise noted, provide combination starter/disconnects for all equipment requiring a starter.

2. ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT

   A. All mechanical equipment shall be provided for single point electrical connection unless specifically noted to the contrary. Refer to schedules and other sections of these specifications for further requirements. It is the responsibility of the Contractor to coordinate the electrical characteristics of all equipment with the electrical provisions indicated on the Contract Documents. The Contractor shall notify the Engineer in writing ten calendar days prior to bid of any discrepancy so a written clarification by Addendum may be made. If such notice is not given, the Contractor shall be responsible for any and all costs or delays associated with any changes required. Specification of equipment characteristics made during review of shop drawings shall not relieve the Contractor of this responsibility.

   B. The equipment manufacturer shall provide internally mounted fuses with his equipment, as required, to comply with the U.L. listing on the equipment name plate. (i.e., hermetically sealed compressors or equipment with name plate data that recommends or requires fuse protection.) See also, National Electrical Code, Article 440, and other applicable sections of the N.E.C.

   C. It is the Contractor's responsibility to furnish and install fusible or non-fusible disconnect switches or circuit breakers for disconnecting means as required by the Code for all electrically powered equipment. All power wiring from source, thru disconnecting means and motor starters to motor terminals or equipment junction box is to be furnished and installed by the Contractor. Each separate contractor engaged for the project shall coordinate with all other trades to ensure all necessary equipment and labor is included for fully functioning mechanical systems, installed per code requirements. Unless otherwise notes, provide combination starter/disconnects for all equipment requiring a starter.

   D. Final electrical connection of equipment shall be verified for proper voltage requirements in conjunction with the motor nameplate patch and actual wiring configuration. Any costs
associated with damage to appliances motors, equipment, etc., connected to incorrect supply voltage shall be borne by the Contractor.

E. Refrigeration condensing units with internal compressors shall be furnished with integral starter. The Contractor is to furnish and install a fusible disconnecting mains with fuses sized to motor nameplate requirements. Coordinate wiring, mounting and style of disconnect switch at unit in field.

F. All interlock or other control wiring, unless specifically noted otherwise, is the responsibility of the Contractor.

G. All equipment shall be suitably enclosed. All enclosures for equipment shall be rated and approved for the environment in which it operates. (i.e., NEMA 1, NEMA 3R, NEMA 7, NEMA 12, etc.) Verify the requirement with the installation condition if not indicated on the plans.

H. Observe the following standards for manufacturers of equipment and selection of components.
   
   (1) Starters, control devices and assemblies: NEMA, U.L. - (I.E.C. style not acceptable)
   
   (2) Enclosures for electrical equipment: NEMA, U.L.
   
   (3) Enclosed switches: NEMA, U.L.
   
   (4) All electrical work, generally: National Electrical Code
   
   (5) All electrical work in industrial occupancies: J.I.C. standards
   
   (6) All electrical components and materials: U.L. listing required.

I. Where required, the Contractor is to provide mounting rails or channels to install starters with code-required clearances. Framing shall be solidly anchored by welding expansion shields in masonry or other approved anchorage. Frames are to be constructed of steel angles or pre-manufactured channel systems such as Unistrut, Kindorf or B-Line Company. Framing material shall be pre-finished with corrosion-resistant material or painted with two coats corrosion-resistant oil-based enamel.

3. REQUIREMENTS FOR MECHANICAL EQUIPMENT, 1/2 H.P OR LESS

A. This section describes requirements for small mechanical equipment such as (but not limited to) package terminal heating/cooling units, (water source heat pumps, etc.) VAV boxes, unit heaters, vertical and horizontal unit ventilators, exhaust fans, in-line fans, fan coil units, cabinet heaters and the like.

B. Small equipment with motor(s) of 1/2 H.P., single phase or less are generally not required to be furnished with NEMA-style starter(s), unless otherwise noted.
C. For such equipment, provide integral contactor or horsepower-rated relay where controlled by thermostat or other type of switch. Contactors or relays shall be as recommended by the manufacturer of the equipment, suitable for the service duty.

D. Provide transformer within unit as required to derive low voltage A.C. for thermostat control or derive from temperature controls panel, if available.

E. Provide internal fusing for unit motor and other loads in fuse block or in-line fuseholder. See also Article 2-B, this Section.

F. Where externally-mounted disconnecting means is required and would be impractical, unsightly or inappropriate in the judgment of the Engineer, disconnects shall be located within the unit. These disconnects may be fusible H.P.-rated snap switches or manual starters with overload elements, as required. Locate this and other electrical equipment within enclosure where easily accessible behind access panel or door on unit, and as acceptable to the electrical inspector or local authority having jurisdiction. Refer to mechanical equipment schedules for further information.

G. Where fractional horsepower duplex pumps such as water circulators, sump pumps, etc. are provided, they shall be provided with alternators, cordsets, etc., as required for a complete installation.

4. REQUIREMENTS FOR MECHANICAL EQUIPMENT, 3/4 H.P. OR LARGER

A. This section describes requirements for mechanical equipment such as (but not limited to) exhaust fans, larger air handling units, cooling tower fans, water source heat pumps, chilled or hot water pumps, D.X. roof-top units, air compressors and the like.

B. Provide premium efficiency motors.

C. Equipment provided with motor(s) of 3/4 H.P. and larger, single or three-phase are required to be furnished with starters suitable for the load(s) specified. It is recommended that starters be furnished integrally with or mounted on equipment for field wiring by the Contractor. Where starters are furnished separate from equipment, furnish templates or rough-in diagrams to the appropriate contractor for his use in installation.

D. All starters shall be size 0 minimum. They shall be constructed and tested in accord with latest edition of NEMA standards. All starters shall be across-the-line magnetic type, unless indicated otherwise. On motors of 20 H.P. or greater rating, the supplier shall provide starters capable of limiting inrush currents. These shall be of the wye-delta, reduced voltage open-transition type, or electronic controlled, as required. Do not utilize closed transition starters unless specifically indicated.

E. Magnetic starters shall be furnished with the following characteristics and accessories as a minimum. See other sections of these specifications and mechanical schedules for further requirements.
(1) Contacts shall be silver-alloy, double-break type. Contacts shall be replaceable without removal of wiring or removal of starter from enclosure. Number of contacts shall be as required for service indicated. Contacts shall be gravity dropout type, positive operation.

(2) Coil voltage shall be 120 volts, A.C., 60 HZ or less, as required to suit control systems available voltages. Coils shall be of molded construction, rated for continuous duty. Provide coil clearing contact as required.

(3) Provide control transformer of adequate K.V.A. as required on all starters with line-to-line voltages higher than 120 volts A.C. Provide fuse block and slow-blow fuse to protect control transformer per NEMA, N.E.C. and U.L.

(4) Provide hand-off-auto selector switch in face of starter, wired into hand and off switch positions. Auto position (if needed) to be field wired as indicated on plans or schedules for automatic control. Provide a green run pilot light.

(5) Provide NEMA Class 20 resettable overload relays, accurately sized to the motor nameplate rating of the motor served and the temperature differential between motor and controller. Overloads shall be easily replaceable, and resettable without opening enclosure, via a push button or similar means. Class 10 or Class 30 overloads may be used, depending on the type of anticipated service.

(6) Provide at least one N.O. and one N.C. auxiliary contact (field-convertible to opposite operation) with each starter. Refer to mechanical details or schedules for additional requirements, if any. All starters shall have space for two additional single-pole contacts.

(7) All starters shall be thru-wiring type.

(8) Provide phase failure sensing relay to open starter coil circuit (on loss of one or more phases) on all three-phase starters controlling motors of 15 H.P. or larger.

(9) Provide power factor correction capacitors on motors of 15 H.P. or larger where predicted power factor based on manufacturer's data will fall below 0.90%. Capacitors shall be of the unit-cell type, in single enclosure with discharge resistors and tank overpressure circuit interrupter for safety.

5. REQUIREMENTS FOR WIRING

A. All wiring, including controls, interlock, miscellaneous power, sensors, thermostats, etc., shall be installed in metallic raceway systems that are in compliance with all Division 16 requirements of these Specifications, unless specifically noted otherwise. Open cabling systems will only be permitted where specifically permitted within the Division 16 Specifications and if less than 50 volts A.C. peak-to-peak or 50 volts maximum D.C.
B. Where open cabling is permitted, it shall be installed with proper support as specified in the Division 16 Specifications.

C. Where open cabling is permitted, and installed in environmental air plenum (return, relief, supply, etc.), the materials installed shall be in compliance with N.E.C. Articles 700, 725, 770 (for fiber optic), 780 and 800.

D. Where open cabling is permitted, it shall only be installed open in accessible spaces. Where concealed in walls, it shall be routed through raceways to outlet boxe(s) for the terminal device.

6. INVERTER DUTY MOTORS

A. Motors which are controlled by variable frequency drive shall be:

(1) NEMA MG-1 Part 31 rated for Inverter Duty.

(2) Furnished with shaft grounding kit for all motors:

a. Motors less than 100 HP in size shall be furnished with shaft grounding kit, Aegis SGR Bearing Protection Ring or equal. One shaft grounding ring and related hardware shall be provided on drive end or non-drive end of motor per manufacturer’s instructions. These shall be factory mounted and installed on the exterior of the motor to allow for visual inspection. Ground motor frame per manufacturer’s instructions. Install kit in strict accordance with manufacturer’s instructions.

b. Motors Pumps greater than 100 HP to 1000 HP in size shall be furnished with shaft grounding kit, Aegis SGR Bearing Protection Ring or equal. Provide shaft grounding ring on drive end and non-drive end of motor per manufacturer’s instructions. Additionally provide insulated bearing journals to further reduce risk of current dissipation through bearings. Ground motor frame per manufacturer’s instructions. Install kit in strict accordance with manufacturer’s instructions.

END OF SECTION 15910
SECTION 15950 - TESTING, BALANCING, LUBRICATION AND ADJUSTMENTS

1. GENERAL

A. The General Conditions, Instructions to Bidders, Section 15000, and other Contract Documents are a part of this specification and shall be binding on all Mechanical Contractors. It shall be each Contractor's responsibility to apprise himself of all information pertinent to his work prior to submitting his proposal. No adjustments will be made in this Contract which is a result of failure to comply with this requirement.

B. The Engineer, or his authorized representative, shall be notified by the Contractor twenty-four (24) hours in advance of any tests called for in these specifications or required by others. Any leaks or imperfections found shall be corrected and a new tests run to the satisfaction of the Engineer or his authorized representative. Upon completion of a test, a written approval of that part of the work will be given to the Contractor. Only after written approval, signed by the Engineer, shall the Contractor apply insulation or paint or allow his work to be furred-in. This written approval, however, does not relieve the Contractor of the responsibilities for any failure during the guarantee period. The expense of all tests shall be borne by the Contractor, along with all temporary equipment, materials, gauges, etc. required for tests.

2. PLUMBING

A. Piping shall be tested before being insulated or concealed in any manner. Where leaks or defects develop, required corrections shall be made and tests repeated until systems are proven satisfactory.

B. Water piping systems shall be subjected to a hydrostatic test of one hundred fifty pounds. The system shall be proven tight after a twenty-four (24) hour test.

C. The house drain line, interior storm sewers, interior rain water conductors, and all soil, waste and vent piping shall be subjected to a hydrostatic test of not less than a 10-foot head or an air test of not less than 5 lbs. per sq. inch using a mercury column gauge and shall hold for 15 minutes.

D. Exterior sewer lines to the termination point outside the building shall be subject to a ten-foot hydrostatic test or an approved smoke test. These lines shall be subjected to a second test after 2 feet of backfill has been properly installed.

E. After fixtures have been installed, the entire plumbing system, exclusive of the house sewer, shall be subjected to an air pressure test equivalent to one inch water column and proven tight. The Contractor responsible shall furnish and install all of the test tees required, including those for isolating any portion of the system for tests.

F. Thermometers and gauges shall be checked for accuracy. If instruments prove defective, they shall be replaced.

G. The Contractor shall perform all additional tests that may be required by the Kentucky Department of Health or other governing agency.

H. Set temperature control on water heaters and adjust tempering valves as required.
I. Balance the water flow rate of each domestic hot water recirculating pump. Set the flow rate for each balancing valve in the recirculating hot water system. If flow rates are not indicated, contact the engineer for each balance valve GPM.

J. Any leaks or imperfections found shall be corrected and a new test run until satisfactory results are obtained. The cost of repair or restoration of surfaces damaged by leaks in any system shall be borne by the Contractor.

K. The compressed air system shall be tested for leaks for eight (8) hours at 250 PSI.

L. The natural gas piping shall be tested in accordance with requirements and/or recommendations of the local gas company.

M. Fuel oil piping shall be static tested at 250 PSI for eight (8) hours.

3. HEATING, VENTILATING AND AIR CONDITIONING

A. The test and balance of this system shall be by a contractor who employs only the services of a certified AABC or independent NEBB firm whose sole business is to perform test and balance services. The test and balance contractor shall report all deficiencies to the engineer.

B. The Mechanical Contractor shall test all piping before being insulated or concealed in any manner. Where leaks or defects develop, required corrections shall be made and tests repeated until systems are proven satisfactory. Water piping systems shall be subjected to a hydrostatic test of not less than one hundred pounds and shall be proven tight after a twenty-four (24) hour test.

C. All motors, bearings, etc. shall be checked and lubricated as required during start-up procedures. All automatic, pressure regulating and control valves shall be adjusted. Excessive noise or vibration shall be eliminated. Provide all start-up documents to Designer prior to any test and balance services.

D. System balancing, where required, shall be performed only by persons skilled in this work. The system shall be balanced as often as necessary to obtain desired system operation and results.

E. All fan belts shall be adjusted for proper operation of fans.

F. All deficiencies observed by the Test and Balance Contractor shall be reported immediately to the Engineer and Mechanical Contractor.

G. For the purpose of placing the heating, ventilating and air conditioning system in operation according to design conditions and certifying same, final testing and balancing shall be performed in complete accordance with AABC Standards for Total System Balance, Volume Six (2002), for air and hydronic systems as published by the Associated Air Balance Council. The following systems shall be test and balance:

(1) The supply, return and outside air duct systems associated with MAU-1 and OA-1. Provide static pressure profiles thru each system. Static pressure profiles shall include all sections from the return duct inlet and supply duct outlet of the air handling unit. Show accurate
representation of return, relief, outdoor and economizer damper locations. On units equipped with return air fans; show location and profile of the return fan.

(2) OA-1 and MAU-1 supply and return duct air leakage testing per Section 15130.

(3) The hot water pumps

(4) Balance all supply, return and exhaust air grille to within 10% of design air flow rate.

(5) Balance all exhaust air fans and record inlet static pressure.

(6) Balance the kitchen rangehood supply/exhaust air system.

(7) Balance domestic hot water return system including all balance valves and record settings and flows.

(8) Provide pre-construction test information on the following systems (______________). Information required is existing AHU air flow rate and static pressure profiles. Determine CFM of each diffuser in project renovation area. Provide 15 duct static pressure measurements where requested by engineer.

(9) Adjust all adjustable diffusers to minimize air drafts and eliminate suspended light fixture sway. Furthermore, adjustable diffusers in spaces with ceilings taller than 9 feet shall be adjusted to eliminate air stratification during heating season.

H. Provide a preliminary test report to the mechanical engineer immediately after the system is air balanced, or any initial phases are balanced. This report may be hand written. Anticipate visiting the site again after the engineer has reviewed the report. The engineer may request up to 15 additional static pressure measurements for any air handling system to help resolve any balancing deficiencies. Include five additional static pressure measurements for each exhaust air system.

I. The Test and Balance agency shall provide lifts, scaffolding, etc. as required to balance devices in areas with high ceilings such as gymnasiums, auditoriums, atriums, cupolas, etc. The Test and Balance agency may coordinate with the General Contractor or Mechanical Contractor to arrange for these items to be provided to access high devices, however, it is emphasized the Contractor is finally responsible for providing the means required to balance all devices.

J. Instruments used for testing and balancing of air and hydronic systems shall have been calibrated within a period of six months prior to balancing. All final test analysis reports shall include a letter of certification listing instrumentation used and last date of calibration.

K. Test and Balance agency is to provide sizing of fan or motor sheaves required for proper balance. The Mechanical Contractor will purchase and install all sheaves and belts as required. This includes new and existing equipment.

L. Four (4) copies of the complete test reports shall be submitted to the Consulting Engineer prior to final acceptance of the project. Preliminary test reports shall be submitted when requested.

M. The Contractor shall provide and coordinate his work in the following manner:
(1) Provide sufficient time before final completion date so that tests and balancing can be accomplished.

(2) Provide immediate labor and tools to make corrections when required without undue delay.

N. The Contractor shall put all heating, ventilating and air conditioning systems and equipment and rangehood system into full operation and shall continue the operation of same during each working day of testing and balancing.

O. The test and balance contractor shall be present during the Engineer’s final inspection of the building, or a separate project review date. The Engineer may request confirmation of the air balance report by asking for new measurements to be taken at that time. Any information in the test and balance report may be asked to be reconfirmed.

P. Balance all water and air systems. Be sure to include:

   (1) Domestic Hot Water Recirculating System.

Q. Automatic Flow Control Balance Valves

   (1) Verify that each installed automatic flow control device matches the GPM indicated on the drawings.

   (2) Verify that the actual pressure at each automatic flow control device is within the pressure limits specified by the valve manufacturer.

   (3) Include documentation of the above information for each control device in the final balance report.

4. FIRE PROTECTION SYSTEM

   A. Test in accord with local Fire Marshall requirements and/or requirements or recommendations of NFPA Regulations.

END OF SECTION 15950
SECTION 15955 - MECHANICAL MAINTENANCE

1. GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, General Conditions-Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified herein.

2. MECHANICAL MAINTENANCE CONTRACT

A. In addition to all other work indicated and specified, the Contractor shall provide the necessary skills and labor to assure the proper operation and to provide all required current preventative maintenance for all equipment and controls provided under Division 15 for a period of one year after substantial completion of the contract as defined in these specifications.

B. The Contractor shall receive calls for any and all problems experienced in the operation of the equipment provided and shall take steps to immediately correct any deficiencies that may exist.

C. The Contractor shall provide monthly inspection of all equipment and record the findings on a check list hereinafter specified.

D. The Contractor shall provide a check list and shall post a copy of it in the main mechanical room. The check list shall be a list of each piece of equipment found in Division 15 of these specifications. The check list shall have a space for each of the next 12 months to provide a space for check-off. The Contractor shall certify on this check list that he has examined each piece of equipment and that, in his opinion, it is operating as intended by the manufacturer, it has been properly lubricated, and that all necessary current and preventative maintenance has been performed as recommended by the manufacturer and by good and accepted practice. This check list shall be approved in writing by the Engineers.

E. All equipment that requires repairing shall be immediately serviced and repaired. Since the period of maintenance runs for one year concurrently with the warranty and guarantee, all parts and labor shall be furnished at no extra cost to the Owner.

F. Control System - Once each month, the Control Sub-Contractor shall check all controls in the building to ascertain that they are functioning as designed and installed. This shall apply to all thermostats, aquastats, humidistats, freezestats, and firestats. This portion of the work shall be performed only by the Sub-Contractor that installed the controls.

G. Filter maintenance shall be a special part of this contract and this Contractor shall inspect all filters once every month and shall clean or replace filter as necessary.

H. When emergency service is required beyond regular working hours to maintain the system in operation, the Contractor shall furnish such service.
I. Failure on the part of the Contractor to comply with all or part of this section of his work, will be required to relinquish a portion of his original contract sum. In general, that cost will be determined by the cost incurred by the owners to have work accomplished which should have, by contract, been accomplished by the Contractor.

END OF SECTION 15955
SECTION 16000 - GENERAL PROVISIONS - ELECTRICAL

1. GENERAL

A. The Instructions to Bidders, General and Special Conditions, and all other contract documents shall apply to the Contractor's work as well as to each of his Sub Contractor's work. Each Contractor is directed to familiarize himself in detail with all documents pertinent to this Contract. In case of conflict between these General Provisions and the General and/or Special Conditions, the affected Contractor shall contact the Engineer for clarification and final determination.

B. The Contractor shall be governed by any alternates, unit prices and Addenda or other contract documents insofar as they may affect his part of the work.

C. The work included in this division consists of the furnishing of all labor, equipment, transportation, supplies, material and appurtenances and performing all operations necessary for the satisfactory installation of complete and operating electrical systems indicated on the drawings and/or specified herein.

D. Any materials, labor, equipment or services not mentioned specifically herein which may be necessary to complete or perfect any part of the electrical systems in a substantial manner, in compliance with the requirements stated, implied, or intended in the drawings and specifications, shall be included as part of this Contract. The Contractor shall give written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules or regulations of authorities having jurisdiction; and any necessary items of work omitted a minimum of ten days prior to bid. In the absence of such written notice and by the act of submitting his bid, it shall be understood that the Contractor has included the cost of all required items in his bid, and that he will be responsible for the approved satisfactory functioning of the entire system without extra compensations.

E. It is not the intent of this section of the specifications (or the remainder of the contract documents) to make any specific Contractor, other than the Contractor holding the prime contract, responsible to the Owner, Architect and Engineer. All transactions such as submittal of shop drawings, claims for extra costs, requests for equipment or materials substitution, shall be done through the Contractor to the Architect (if applicable), then to the Engineer.

F. This section of the Specifications or the arrangement of the contract documents shall not be construed as an attempt to arbitrarily assign responsibility for work, material, equipment or services to a particular trade Contractor or Sub-Contractor. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be the responsibility of the Contractor holding the prime contract.

G. It is the intent of this Contract to deliver to the Owner a "like new" project once work is complete. Although plans and specifications are complete to the extent possible, it shall be responsibility of the Contractors involved to remove and/or relocate or re-attach any existing or
new systems which interfere with new equipment or materials to be installed by other trades without additional cost to the Owner.

H. In general, and to the extent possible, all work shall be accomplished without interruption of the existing facilities' operations. Each Contractor shall advise the Architect, Owner and Engineer (as applicable) in writing at least one week prior to the deliberate interruption of any services. The Owner shall be advised of the exact time that interruption will occur and the length of time the interruption will occur. Failure to comply with this requirement may result in complete work stoppage by the Contractors involved until a complete schedule of interruptions can be developed.

I. Whenever utilities are interrupted, either deliberately or accidentally, the Contractor shall work continuously to restore said service. The Contractor shall provide tools, materials, skilled journeymen of his own and other trades as necessary, premium time as needed and coordination with all applicable utilities, including payment of utility company charges (if any), all without request for extra compensation to the Owner, except where otherwise provided for in the contract document.

J. The Contractor shall be responsible for maintaining existing fire alarm, paging, access control, intrusion detection, CCTV, nurse call systems, etc., in occupied spaces in renovation and addition projects. The Contractor shall be required to disconnect and remove all existing devices in renovated areas (where directed as such) without affecting system operations. All costs associated with said work shall be borne by the Contractor.

K.

L. Definitions:

(1) Prime Contractor - The Contractor who has been engaged by the Owner in a contractual relationship to accomplish the work.

(2) Electrical Contractor - Any Contractor whether bidding or working independently or under the supervision of a General Contractor, that is: the one holding the Prime Contract and who installs any type of Electrical work, such as: power, lighting, television, telecommunications, data, fiber optic, intercom, fire detection and alarm, security, video, underground or overhead electrical, etc.

Note: Any reference within these specifications to a specific entity, i.e., "Electrical Contractor" is not to be construed as an attempt to limit or define the scope of work for that entity or assign work to a specific trade or contracting entity. Such assignments of responsibility are the responsibility of the Contractor or Construction Manager holding the prime contract, unless otherwise provided herein.

(3) Electrical Sub-Contractor - Each or any Contractor contracted to, or employed by, the Electrical Contractor for any work required by the Electrical Contractor.
(4) Engineer - The Consulting Mechanical-Electrical Engineers, either consulting to the Owner, Architect, other Engineers, etc.

(5) Architect - The Architect of Record for the project, if any.

(6) Furnish - Deliver to the site in good condition.

(7) Provide - Furnish and install in complete working order.

(8) Install - Install equipment furnished by others in complete working order.

(9) Contract Documents - All documents pertinent to the quality and quantity of all work to be performed on the project. Includes, but not limited to: Plans, Specifications, Addenda, Instructions to Bidders, (both General and Sub-Contractors), Unit Prices, Shop Drawings, Field Orders, Change Orders, Cost Breakdowns, Construction Manager's Assignments, Architect's Supplemental Instructions, Periodical Payment Requests, etc.

2. INTENT

A. It is the intent of these specifications and all associated drawings that the Contractor provide finished work, tested, and ready for operation. Wherever the word "provide" is used, it shall mean "furnish and install complete and ready for use."

B. Minor details not usually shown or specified, but necessary for the proper installation and operation, shall be included in the work, the same as if herein specified or shown.

3. ELECTRICAL DRAWINGS AND SPECIFICATIONS

A. The drawings are diagrammatic only and indicate the general arrangement of the systems and are to be followed insofar as possible. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted in writing to the Engineer for review before proceeding with the work. The Contract Drawings are not intended to show every vertical or horizontal offset which may be necessary to complete the systems. Contractors shall, however, anticipate that additional offsets may be required and submit their bid accordingly.

B. The drawings and specifications are intended to supplement each other. No Contractor or supplier shall take advantage of conflict between them, or between parts of either, but should this condition exist, the Contractor or supplier shall request a clarification of the condition at least ten days prior to the submission of bids so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be the determining factor. In all instances, unless modified in writing and agreed upon by all parties thereto, the Contract to accomplish the work shall be binding on the affected Contractor.

C. The drawings and specifications shall be considered to be cooperative and complimentary and anything appearing in the specifications which may not be indicated on the drawings or
conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.

D. The Contractor shall make all his own measurements in the field and shall be responsible for correct fitting. He shall coordinate this work with all other branches of work in such a manner as to cause a minimum of conflict or delay.

E. The Engineer shall reserve the right to make minor adjustments in location of conduit, fixtures, outlets, switches, etc., where he considers such adjustments desirable in the interest of concealing work or presenting a better appearance.

F. The Contractor shall evaluate ceiling heights called for on Architectural Plans. Where the location of Electrical equipment may interfere with ceiling heights, the Contractor shall call this to the attention of the Engineer in writing prior to making the installation. Any such changes shall be anticipated and requested sufficiently in advance so as to not cause extra work on the part of the Contractor or unduly delay the work.

G. Special Note: Always check ceiling heights indicated on Drawings and Schedules and insure that these heights may be maintained after all mechanical and electrical equipment is installed. If a conflict is apparent, notify the Engineer in writing for instructions.

H. Should overlap of work between the various trades become evident, this shall be called to the attention of the Engineer. In such event neither trade shall assume that he is to be relieved of the work which is specified under his branch until instructions in writing are received from the Engineer.

I. The drawings are intended to show the approximate location of equipment, materials, etc. Dimensions given in figures on the drawings shall take precedence over scaled dimensions and all dimensions whether given in figures or scaled shall be verified in the field. In case of conflict between small and large scale drawings, the larger scale drawings shall take precedence.

J. The Contractor and his Sub Contractors shall review all drawings in detail as they may relate to his work (structural, architectural, site survey, mechanical, etc.). Review all drawings for general coordination of work, responsibilities, ceiling clearances, wall penetration points, chase access, fixture elevations, etc. Make any pertinent coordination or apparent conflict comments to the Engineers at least ten days prior to bids, for issuance of clarification by written addendum.

K. Where on any of the drawings a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornament or other detail is indicated by starting only, such detail shall be continued throughout the courses or parts in which it occurs and shall also apply to all other similar parts of the work, unless otherwise indicated.

4. EXAMINATION OF SITE AND CONDITIONS
A. The Contractor shall inform himself of all of the conditions under which the work is to be performed, the site of the work, the structure of the ground, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work. All Contractors or suppliers shall carefully examine all Drawings and Specifications and contract documents to determine the kind and type of materials to be used throughout the project and which may, in any way, affect the execution of his work.

B. The Contractor shall fully acquaint himself with all existing conditions as to ingress and egress, distance of haul from supply points, routes for transportation of materials, facilities and services, availability of temporary or permanent utilities, etc. The Contractor shall include in his work all expenses or disbursements in connection with such matters and conditions. The Contractor shall verify all work shown on the drawings and conditions at the site, and shall report in writing to the Engineer ten days prior to bid, any apparent omissions or discrepancies in order that clarifications may be issued by written addendum. No allowance is to be made for lack of knowledge concerning such conditions after bids are accepted.

5. EQUIPMENT AND MATERIALS SUBSTITUTIONS OR DEVIATIONS

A. When any Contractor requests review of substitute materials and/or equipment, and when under an approved formal alternate proposal, it shall be understood and agreed that such substitution, if approved, will be made without additional cost regardless of changes in connections, spacing, service, mounting, etc. In all cases where substitutions affect other trades, the Contractor offering such substitutions shall advise all such Contractors of the change and shall reimburse them for all necessary changes in their work. Any drawings, Specifications, Diagrams, etc., required to describe and coordinate such substitutions or deviations shall be professionally prepared at the responsible Contractor's expense. Special Note: Review of Shop Drawings by the Engineer does not absolve the Contractor of this responsibility

B. References in the specifications to any article, device, product, material, fixture, form, or type of construction by name, make, or catalog number shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition. Each Contractor, in such cases, may, at his option, use any article, device, product, material, fixture, form, or type of construction which in the judgment of the Engineer is equivalent to that specified, provided the provisions of paragraph (A) immediately preceding are met. Substitutions shall be submitted to the Engineer a minimum of ten days prior to bid date for approval to bid in written form thru addenda or other method selected by the Engineer. If prevailing laws of cities, towns, states or countries are more stringent than these specifications regarding such substitutions, then those laws shall prevail over these requirements.

C. Wherever any equipment and material is specified exclusively only such items shall be used unless substitution is accepted in writing by the engineers.

D. The Contractor shall furnish along with his proposal a list of specified equipment and materials which he proposes to provide. Where several makes are mentioned in the Specifications and the Contractor fails to state which he proposes to furnish, the Engineer shall have the right to choose any of the makes mentioned without change in price.
E. The Contractor shall review the contract documents and if a material substitution form is required for each proposed substitution, it shall be submitted per requirements.

6. SUPERVISION OF WORK

A. Each Contractor and Sub-Contractors shall personally supervise the work or have a competent superintendent on the project site at all times during progress of the work, with full authority to act for him in matters related to the project.

7. CODES, RULES, PERMITS, FEES, REGULATIONS, ETC.

A. The Contractor shall give all necessary notices, obtain and pay for all permits, government sales taxes, fees, and other costs including utility connections or extensions, in connection with his work. As necessary, he shall file all required plans, utility easement requests and drawings, survey information on line locations, load calculations, etc., prepare all documents and obtain all necessary approvals of all utility and governmental departments having jurisdiction; obtain all required certificates of inspection for his work and deliver same to the Engineer before request for acceptance and final payment for the work.

B. Ignorance of Codes, Rules, regulations, utility company requirements, laws, etc., shall not diminish or absolve Contractor's responsibilities to provide and complete all work in compliance with such.

C. The Contractor shall include in the work, without extra cost, any labor, materials, services, apparatus or drawings required in order to comply with all applicable laws, ordinances rules and regulations, whether or not shown on drawings and/or specified.

D. All materials furnished and all work installed shall comply with the current edition of the National Electrical Codes, National Fire Codes of the National Fire Protection Association, the requirements of local utility companies, and with the requirements of all governmental agencies or departments having jurisdiction.

E. All material and equipment for the electrical systems shall bear the approval label, or shall be listed by the Underwriters' Laboratories, Incorporated. Listings by other testing agencies may be acceptable with written approval by the Engineer.

F. All electrical work is to be constructed and installed in accordance with plans and specifications which have been approved in their entirety and/or reflect any changes requested by the State Fire Marshal, as applicable or required. Electrical work shall not commence until such plans are in the hands of the Electrical Contractor.

G. The Contractor shall insure that his work is accomplished in accord with OSHA Standards and any other applicable government requirements.
H. Where conflict arises between any code and the plans and/or specifications, the code shall apply except in the instance where the plans and specifications exceed the requirements of the code. Any changes required as a result of these conflicts shall be brought to the attention of the Engineer at least ten working days prior to bid date, otherwise the Contractor shall make the required changes at his own expense. The provisions of the codes constitute minimum standards for wiring methods, materials, equipment and construction and compliance therewith will be required for all electrical work, except where the drawings and specifications require better materials, equipment, and construction than these minimum standards, in which case the drawings and specifications shall be the minimum standards.

8. COST BREAKDOWNS/SCHEDULE OF VALUES

A. Within thirty days after acceptance of the Contract, the Contractor is required to furnish to the Engineer one copy of a detailed cost breakdown on each respective area of work. These cost breakdowns shall be made on forms provided or approved by the Engineer or Architect. Payments will not be made until satisfactory cost breakdowns are submitted. Refer to the end of this section for a sample of expected level and breakout being required.

9. CORRECTION PERIOD

A. All equipment, apparatus, materials, etc., shall be the best of its respective kind. The Contractor shall replace all materials at his own expense, which fail or are deemed defective as described in the General Conditions. The effective date of completion of the work shall be the date each or any portion of the work is accepted by the Architect or Engineer as being substantially complete.

B. Items of equipment which have longer guarantees, as called for in these specifications or as otherwise offered by the manufacturer, such as generators, engines, batteries, transformers, etc., shall have warranties and guarantees completed in order, and shall be in effect at the time of final acceptance of the work by the Engineer. The Contractor shall present the Engineer with such warranties and guarantees at the time of final acceptance of the work. The Owner reserves the right to use equipment installed by the Contractor prior to date of final acceptance. Such use of equipment shall in no way invalidate the guarantee except that Owner shall be liable for any damage to equipment during this period due to negligence of his operator or other employee.

10. INSPECTION, APPROVALS AND TESTS

A. Before requesting a final review of the installation from the Architect and/or Engineer, the Contractor shall thoroughly inspect his installation to assure that the work is complete in every detail and that all requirements of the Contract Documents have been fulfilled. Failure to accomplish this may result in charges from the Architect and/or Engineers for unnecessary and undue work on their part.

B. The Contractor shall provide as part of this contract electrical inspection by a competent Electrical Inspection Agency, licensed to provide such services in the Commonwealth of Kentucky. The name of this agency shall be included in the list of materials of the Form of Proposal by the Contractor. All costs incidental to the provision of electrical inspections shall be borne by the Electrical Contractor.
C. The Contractor shall advise each Inspection Agency in writing (with an information copy of the correspondence to the Architect and/or Engineer) when he anticipates commencing work. Failure of the Inspection Agency to inspect the work in the stage following and submit the related reports may result in the Contractor’s having to expose concealed work not so inspected. Such exposure will be at the expense of the responsible Contractor.

D. Inspections shall be scheduled for rough as well as finished work. The rough inspections shall be divided into as many inspections as may be necessary to cover all roughing-in without fail. Report of each such inspection visit shall be submitted to the Architect, Engineer and the Contractor within three days of the inspection.

E. Approval by an Inspector does not relieve the Contractor from the responsibilities of furnishing equipment having a quality of performance equivalent to the requirements set forth in these plans and specifications. All work under this contract is subject to the review of the Architect and/or Engineer, whose decision is binding.

F. Before final acceptance, the Contractor shall furnish three copies of the certificates of final approval by the Electrical Inspector (as well as all other inspection certificates) to the Engineer with one copy of each to the appropriate government agencies, as applicable. Final payment for the work shall be contingent upon completion of this requirement.

G. The Contractor shall test all wiring and connections for cross connects, continuity and grounds before equipment and fixtures are connected, and when indicated or required, demonstrate by continuity/load/voltage test and Megger Test the installation of any circuit or group of circuits. Where such tests indicate the possibility of faulty insulation, locate the point of such fault, replacing same with new and demonstrate by further test the elimination of such defect. The secondary service entrance conductors from the utility (source) transformer to the main service disconnecting means shall be megger tested. The results of this test shall be turned over to the engineer for review and approval. Any conductor failing the test shall be replaced and any costs associated shall be borne by the contractor.

11. COMPUTER-BASED SYSTEM SOFTWARE

A. For all equipment, controls, hardware, computer-based systems, programmable logic controllers, and other materials provided as a part of the work, software that is installed shall be certified in writing to the Engineer and Owner by the manufacturer and/or writer to be free of programming errors that might affect the functionality of the intended use.

12. CHANGES IN ELECTRICAL WORK

REFER TO GENERAL AND SPECIAL CONDITIONS.

13. CLAIMS FOR EXTRA COST

REFER TO GENERAL AND SPECIAL CONDITIONS.
14. SURVEYS, MEASUREMENTS AND GRADES

A. The Contractor shall lay out his work and be responsible for all necessary lines, levels, elevations and measurements. He must verify the figures shown on the drawings before laying out the work and will be held responsible for any error resulting from his failure to do so.

B. The Contractor shall base all measurements, both horizontal and vertical from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at site and check the correctness of same as related to the work.

C. Should the Contractor discover any discrepancy between actual measurements and those indicated, which prevents following good practice or the intent of the drawings and specifications, he shall notify the Engineer thru normal channels of job communication and shall not proceed with his work until he has received instructions from the Engineer.

15. TEMPORARY USE OF EQUIPMENT

A. The permanent electrical equipment, when installed, may be used for temporary services, subject to an agreement among the Contractors involved, the Owner, and with the consent of the Engineer. Should the permanent systems be used for this purpose, each Contractor shall pay for all temporary connections required and any replacements required due to damage without cost, leaving the equipment and installation in "as new" condition. The Contractor may be required to bear utility costs, user fees, etc.

B. Permission to use the permanent equipment does not relieve the Contractors who utilize this equipment from the responsibility for any damages to the building construction and/or equipment which might result because of its use.

16. TEMPORARY SERVICES

A. The Contractor shall arrange for temporary electrical and other services which he may require to accomplish his work. In the absence of other provisions in the contract, the Contractor shall provide for his own temporary services of all types, including the cost of connections, utility company fees, construction, removal, etc., in his bid.

17. RECORD DRAWINGS

A. The Contractor shall insure that any deviations from the design are being recorded daily or as necessary on record drawings being maintained by the Contractor. Dimensions from fixed, visible permanent lines or landmarks shown in vertical and horizontal ways shall be utilized. Compliance shall be a requirement for final payment. Pay particular attention to the location of underfloor or underground exterior in-contract or utility-owned or leased service lines, main switches and other appurtenances important to the maintenance and safety of the Electrical System. Keep information in a set of drawings set aside at the job site especially for this purpose. Deliver these record drawings electronically to the Engineer in AutoCad 2000 format.
18. MATERIALS AND WORKMANSHIP

A. All electrical equipment, materials and articles incorporated in the work shall be new and of comparable quality to that specified. All workmanship shall be first-class and shall be performed by electricians skilled and regularly employed in their respective trades. The Contractor shall determine that the equipment he proposes to furnish can be brought into the building(s) and installed within the space available. All equipment shall be installed so that all parts are readily accessible for inspection, maintenance, replacement, etc. Extra compensation will not be allowed for relocation of equipment for accessibility or for dismantling equipment to obtain entrance into the building(s).

B. All conduit and/or conductors shall be concealed in or below walls, floors or above ceilings unless otherwise noted. All fixtures, devices and wiring required shall be installed to make up complete systems as indicated on the drawings and specified herein.

C. All materials, where applicable, shall bear Underwriters' Laboratories label or that of another Engineer-approved testing agency, where such a standard has been established.

D. Each length of conduit, wireway, duct, conductor, cable, fitting, fixture and device used in the electrical systems shall be stamped or indelibly marked with the makers mark or name.

E. All electrical equipment shall bear the manufacturer's name and address and shall indicate its electrical capacity and characteristics.

F. All electrical materials, equipment and appliances shall conform to the latest standards of the National Electric Manufacturers Association (NEMA) and the National Board of Fire Underwriters (NBFU) and shall be approved by the Owner's insuring agency if so required.

19. QUALIFICATIONS OF WORKMEN

A. All electrical work shall be accomplished by qualified workmen competent in the area of work for which they are responsible. Untrained and incompetent workmen as evidenced by their workmanship shall be relieved of their responsibilities in those areas. The Engineer shall reserve the right to determine the quality of workmanship of any workman and unqualified or incompetent workmen shall refrain from work in areas not satisfactory to him. Requests for relief of a workman shall be made through the normal channels of responsibility established by the Architect or the contract document provisions.

B. All electrical work shall be accomplished by Journeymen electricians under the direct supervision of a licensed Electrician. All applicable codes, utility company regulations, laws and permitting authority of the locality shall be fully complied with by the Contractor.
C. Special electrical systems, such as Fire Detection and Alarm Systems, Intercom or Sound Reinforcement Systems, Telecommunications or Data Systems, Lightning Protection Systems, Video Systems, Special Electronic Systems, Control Systems, etc., shall be installed by workmen normally engaged or employed in these respective trades. As an exception to this, where small amounts of such work are required and are, in the opinion of the Engineer, within the competency of workmen directly employed by the Contractor involved, they may be provided by this Contractor.

20. CONDUCT OF WORKMEN

A. The Contractor shall be responsible for the conduct of all workmen under his supervision. Misconduct on the part of any workmen to the extent of creating a safety hazard, or endangering the lives and property of others, shall result in the prompt relief of that workman. The consumption or influence of alcoholic beverages, narcotics or illegally used controlled substances on the jobsite is strictly forbidden.

21. COOPERATION AND COORDINATION BETWEEN TRADES

A. The Contractor is expressly directed to read the General Conditions and all detailed sections of these specifications for all other trades and to study all drawings applicable to his work, including Architectural, Mechanical, Structural and other pertinent Drawings, to the end that complete coordination between trades will be effected.

B. Refer to Coordination Among Trades, Systems Interfacing and Connection of Equipment Furnished by Others section of these Specifications for further coordination requirements.

22. PROTECTION OF EQUIPMENT

A. The Contractor shall be entirely responsible for all material and equipment furnished by him in connection with his work and special care shall be taken to properly protect all parts thereof from damage during the construction period. Such protection shall be by a means acceptable to the Engineer. All rough-in conduit shall be properly plugged or capped during construction in a manner approved by the Engineer. Equipment damaged while stored on site either before or after installation shall be repaired or replaced (as determined by the Engineer) by the responsible Contractor.

23. CONCRETE WORK

A. The Contractor shall be responsible for the provision of all concrete work required for the installation of any of his systems or equipment. If this work is provided by another trade, it will not relieve the Electrical Contractor of his responsibilities relative to dimensions, quality of workmanship, locations, etc. In the absence of other concrete specifications, all concrete related to Electrical work shall be 3000 PSI minimum compression strength at 28 days curing and shall conform to the standards of the American Concrete Institute Publication ACI-318. Heavy equipment shall not be set on pads for at least seven days after pour.
B. All concrete pads shall be complete with all pipe sleeves, embeds, anchor bolts, reinforcing steel, concrete, etc., as required. Pads larger than 18" in width shall be reinforced with minimum #4 round bars on 6" centers both ways. All reinforcing steel shall be per ASTM requirements, tied properly, lapped 18 bar diameters and supported appropriately up off form, slab or underlayment. Bars shall be approximately 3" above the bottom of the pad with a minimum 2" cover. All parts of pads and foundations shall be properly rodded or vibrated. If exposed parts of the pads and foundations are rough or show honeycomb after removing forms properly adhered repairs shall be made. If structural integrity is violated, the concrete shall be replaced. All surfaces shall be rubbed to a smooth finish.

Special Note: All pads and concrete lighting standard bases shall be crowned slightly so as to avoid water ponding beneath equipment.

C. In general, concrete pads for small equipment shall extend 6" beyond the equipment's base dimensions. For large equipment with service access panels, extend pads 18" beyond base or overall dimensions to allow walking and servicing space at locations requiring service access.

D. Exterior concrete pads shall be 4" minimum above grade and 4" below grade on a tamped 4" dense grade rock base unless otherwise noted or required by utility company. Surfaces of all foundations and bases shall have a smooth finish with three-quarter inch radius or chamfer on exposed edges, trowelled or rubbed smooth. All exterior pads shall be crowned approximately 1/8" per foot, sloping from center for drainage.

24. RESTORATION OF NEW OR EXISTING SHRUBS, PAVING, ETC.

A. The Contractor shall restore to their original condition all paving, curbing surfaces, drainage ditches, structures, fences, shrubs, existing or new building surfaces and appurtenances, and any other items damaged or removed by his operations. Replacement and repairs shall be in accordance with good construction practice and shall match materials employed in the original construction of the item to be replaced. All repairs shall be to the satisfaction of the Engineer, and in accord with the Architect's standards for such work, as applicable.

25. MAINTENANCE OF EXISTING UTILITIES AND LINES

A. The locations of all piping, conduits, cables, utilities and manholes existing, or otherwise, that come within the contract construction site, shall be subject to continuous uninterrupted maintenance with no exception unless the Owner of the utilities grants permission to interrupt same temporarily, if need be. Provide one week's written notice to Engineer, Architect and Owner prior to interrupting any utility service or line. Also see Article 1. - General, this section.

B. Known utilities and lines as available to the Engineer are shown on the drawings. However, it is additionally required that, prior to any excavation being performed, each Contractor ascertain that no utilities or lines, known or unknown, are endangered by the excavation.
C. If the above mentioned utilities or lines occur in the earth within the construction site, the Contractor shall first probe and make every effort to locate the lines prior to excavating in the respective area. Electromagnetic utility locators and acoustic pipe locators shall be utilized to determine where metallic and non-metallic piping is buried prior to any excavation.

D. Cutting into existing utilities and services shall be done in coordination with and as designated by the Owner of the utility. The Contractor shall work continuously to restore service(s) upon deliberate or accidental interruption, providing premium time and materials as needed without extra claim to the Owner.

E. The Contractor shall repair to the satisfaction of the Engineer any surface or subsurface improvements damaged during the course of the work, unless such improvement is shown to be abandoned or removed.

F. Machine excavation shall not be permitted within ten feet of existing gas or fuel lines. Hand excavate only in these areas, in accord with utility company, agency or other applicable laws, standards or regulations.

G. Protect all new or existing lines from damage by traffic, etc. during construction.

H. Protect existing trees, indicated to remain with fencing or other approved method. Hold all new subsurface lines outside the drip line of trees, offsetting as necessary to protect root structures. Refer to planting or landscaping plans, or in their absence, consult with the Architect.

26. SMOKE AND FIRE PROOFING

A. The Contractor shall not penetrate rated fire walls, ceilings or floors with conduit, cable, bus duct, wireway or other raceway system unless all penetrations are protected in a code compliant manner which maintains the rating of the assembly. Smoke and fire stop all openings made in walls, chases, ceiling and floors. Patch all openings around conduit, wireway, bus duct, etc., with appropriate type material to smoke stop walls and provide needed fire rating at fire walls, ceilings and floors. Smoke and fire proofing materials and method of application shall be approved by the local authority having jurisdiction.

27. QUIET OPERATION, SUPPORTS, VIBRATION AND OSCILLATION

A. All work shall operate under all conditions of load without any objectionable sound or vibration, the performance of which shall be determined by the Engineer. Noise from moving machinery or vibration noticeable outside of room in which it is installed, or annoyingly noticeable noise or vibration inside such room, will be considered objectionable. Sound or vibration conditions considered objectionable by the Engineer shall be corrected in an approved manner by the Contractor (or Contractors responsible) at his expense.

B. All equipment subject to vibration and/or oscillation shall be mounted on vibration supports suitable for the purpose of minimizing noise and vibration transmission, and shall be isolated
from external connections such as piping, ducts, etc., by means of flexible connectors, vibration absorbers or other approved means. Surface mounted equipment such as panels, switches, etc., shall be affixed tightly to their mounting surface.

C. The Contractor shall provide supports for all equipment furnished by him using an approved vibration isolating type as needed. Supports shall be liberally sized and adequate to carry the load of the equipment and the loads of attached equipment, piping, etc. All equipment shall be securely fastened to the structure either directly or indirectly through supporting members by means of bolts or equally effective means. No work shall depend on the supports or work of unrelated trades unless specifically authorized in writing by the Architect or Engineer.

28. FINAL CONNECTIONS TO EQUIPMENT

A. The roughing-in and final connections to all electrically operated equipment furnished under this and all other sections of the contract documents or by others, shall be included in the Contract and shall consist of furnishing all labor and materials for connection. The Contractor shall carefully coordinate with equipment suppliers, manufacturers representatives, the vendor or other trades to provide complete electrical and dimensional interface to all such equipment (kitchen, hoods, mechanical equipment, panels, refrigeration equipment, etc.).

29. WELDING

A. The Contractor shall be responsible for quality of welding done by his organization and shall repair or replace any work not done in accordance with the Architect's or structural Engineer's specifications for such work. If required by the Engineer, the responsible Contractor shall cut at least three welds during the job for X-raying and testing. These welds are to be selected at random and shall be tested as a part of the responsible Contractor's work. Certification of these tests and X-rays shall be submitted, in triplicate, to the Engineer. In case a faulty weld is discovered, the Contractor shall be required to furnish additional tests and corrective measures until satisfactory results are obtained.

30. ACCESSIBILITY

A. The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate clearance in partitions and above suspended ceilings for the proper installation of his work. He shall cooperate with the General Contractor (or Construction Manager) and all other Contractors whose work is in the same space, and shall advise each Contractor of his requirements. Such spaces and clearances shall be kept to the minimum size required to ensure adequate clearance and access.

B. The Contractor shall locate all equipment which must be serviced, operated, or maintained in fully accessible positions. Equipment shall include but not be limited to junction boxes, pull boxes, contactors, panels, disconnects, controllers, switchgear, etc. Minor deviations from drawings may be made to allow for better accessibility, and any change shall be approved where the equipment is concealed.
C. Each Contractor shall provide (or arrange for the provision by other trades) the access panels for each concealed junction box, pull box, fixtures or electrical device requiring access or service as shown on Engineer's plans or as required. Locations of these panels shall be identified in sufficient time to be installed in the normal course of work. All access panels shall be installed in accord with the Architect's standards for such work.

D. Access Doors; in Ceilings or Walls:

1. In mechanical, electrical, or service spaces:

   14 gauge aluminum brushed satin finish, 1" border.

2. In finished areas:

   14 gauge primed steel with 1" border to accept the architectural finishes specified for the space. Confirm these provisions with the Architect prior to obtaining materials or installing any such work.

3. In fire or smoke rated partitions, access doors shall be provided that equal or exceed the required rating of the construction they are mounted in.

31. ELECTRICAL CONNECTIONS

A. The Contractor shall furnish and install all power wiring complete from power source to motor or equipment junction box, including power wiring through starters. The Contractor shall install all starters not factory mounted on equipment. Unless otherwise noted, the supplier of equipment shall furnish starters with the equipment. Also refer to Divisions 11, 14, 20, 21, 22, 23 and 25 of the Specifications, shop drawings and equipment schedules for additional information.

B. All control, interlock, sensor, thermocouple and other wiring required for equipment operation shall be provided by the Contractor. All such installations shall be fully compliant with all requirements of Division 26 and 27 regardless of which trade actually installs such wiring. Motors and equipment shall be provided for current and voltage characteristics as indicated or required. All wiring shall be enclosed in raceways unless otherwise noted.

C. Each Contractor or sub-contractor, prior to bidding the work, shall coordinate power, control, sensor, interlock and all other wiring requirements for equipment or motors with all other contractors or sub-contractors, to ensure all needed wiring is provided in the Contract. Failure to make such coordination shall not be justification for claims of extra cost or a time extension to the Contract.

32. MOTORS

A. Each motor shall be provided by the equipment supplier, installer or manufacturer with conduit terminal box and N.E.C. required disconnecting means as indicated or required. Three-phase
motors shall be provided with external thermal overload protection in their starter units. Single-phase motors shall be provided with thermal overload protection, integral to their windings or external, in control unit. All motors shall be installed with NEMA-rated starters as specified and shall be connected per the National Electrical Code.

B. The capacity of each motor shall be sufficient to operate associated driven devices under all conditions of operation and load and without overload, and at least of the horsepower indicated or specified. Each motor shall be selected for quiet operation, maximum efficiency and lowest starting KVA per horsepower as applicable. Motors producing excessive noise or vibration shall be replaced by the responsible contractor. See Division 20, 22 and 23 of the Specifications for further requirements and scheduled sizes.

33. CUTTING AND PATCHING

A. Unless otherwise indicated or specified, the Contractor shall provide cutting and patching necessary to install the work specified in this Division. Patching shall match adjacent surfaces to the satisfaction of the Engineer and shall be in accord with the Architect's standards for such work, as applicable.

B. No structural members shall be cut without the approval of the Structural Engineer and all such cutting shall be done in a manner directed by him.

C. When installing conduit, pipe, or any other work in insulated concrete form (ICF) walls, the responsible subcontractor for the work shall provide spray foam insulation to patch the rigid insulation to maintain full integrity of the insulating value of the wall after the mechanical and electrical work is complete. Furthermore all new work shall NOT be installed in concrete center of wall. All mechanical and electrical installations shall be on the interior side of the concrete.

34. ANCHORS

A. Each Contractor shall provide and locate all inserts required for his work before the floors and walls are built, or shall be responsible for the cost of cutting and patching required where inserts were not installed, or where incorrectly located. Each Contractor shall do all drilling required for the installation of his hangers. Drilling of anchor holes may be prohibited in post-tensioned concrete construction, in which case the Contractor shall request approved methods from the Architect and shall carefully coordinate setting of inserts, etc., with the Structural Engineer and/or Architect.

35. WEATHERPROOFING

A. Where any work pierces waterproofing, including waterproof concrete, the method of installation shall be as approved by the Architect and/or Engineer before work is done. The Contractor shall furnish all necessary sleeves, caulking and flashing required to make openings absolutely watertight.
B. Wherever work penetrates roofing, it shall be done in a manner that will not diminish or void the roofing guarantee or warranty in any way. Coordinate all such work with the roofing installer.

36. OPERATING INSTRUCTIONS

A. Upon completion of all work and all tests, each Contractor shall furnish the necessary skilled labor and helpers for operating his systems and equipment for a period of three days of eight hours each, or as otherwise specified. During this period, instruct the Owner or his representative fully in the operations, adjustment, and maintenance of all equipment furnished. Give at least one week's written notice to the Owner, Architect and Engineer in advance of this period. The Engineer may attend any such training sessions or operational demonstrations. The Contractor shall certify in writing to the Engineer that such demonstrations have taken place, noting the date, time and names of the Owner's representative that were present.

B. Each Contractor shall furnish three complete bound sets for approval to the Engineer of typewritten and/or blueprinted instructions for operating and maintaining all systems and equipment included in this contract. All instructions shall be submitted in draft, for approval, prior to final issue. Manufacturer's advertising literature or catalogs will not be acceptable for operating and maintenance instructions.

C. Each Contractor, in the above mentioned instructions, shall include the maintenance schedule for the principal items of equipment furnished under this contract and a detailed, easy to read parts list and the name and address of the nearest source of supply.

D. Formatting & content shall follow the guidelines outlined in the latest version of ASHRAE Applications Handbook, Guideline 4. As a minimum, the following shall be included:

- The operation and maintenance document directory should provide easy access and be well organized and clearly identified.
- Emergency information should be immediately available during emergencies and should include emergency and staff and/or agency notification procedures.
- The operating manual should contain the following information:

  I. General Information
     a. Building function
     b. Building description
     c. Operating standards and logs

  II. Technical Information
     a. System description
     b. Operating routines and procedures
     c. Seasonal start-up and shutdown
     d. Special procedures
     e. Basic troubleshooting
The maintenance manual should contain the following information:

I. Equipment data sheets
   a. Operating and nameplate data
   b. Warranty

II. Maintenance program information
   a. Manufacturer’s installation, operation, and maintenance instructions
   b. Spare parts information
   c. Preventive maintenance actions
   d. Schedule of actions
   e. Action description
   f. History

Test reports document observed performance during start-up and commissioning.

37. SCAFFOLDING, RIGGING AND HOISTING

A. The Contractor shall furnish all scaffolding, rigging, hoisting, and services necessary for erection and delivery into the premises of any equipment and apparatus furnished. Remove same from premises when no longer required.

38. CLEANING

A. The Contractor shall, at all times, keep the area of his work presentable to the public and clean of rubbish caused by his operations; and at the completion of the work, shall remove all rubbish, all of his tools, equipment, temporary work and surplus materials, from and about the premises, and shall leave the work clean and ready for use. If the Contractor does not attend to such cleaning immediately upon request, the Engineer may cause cleaning to be done by others and charge the cost of same to the responsible Contractor. Each Contractor shall be responsible for all damage from fire which originates in, or is propagated by, accumulations of his rubbish or debris.

B. After completion of all work and before final acceptance of the work, each Contractor shall thoroughly clean all equipment and materials and shall remove all foreign matter such as grease, dirt, plaster, labels, stickers, etc., from the exterior of materials, equipment and all associated fabrication. Pay particular attention to finished area surfaces such as lighting fixture lenses, lamps, reflectors, panels, etc.

39. PAINTING

A. Each fixture device, panel, junction box, etc., that is located in a finished area shall be provided with finish of color and type as selected or approved by the Architect or Engineer. If custom color is required, it shall be provided at no additional cost to the Owner. All other equipment, fixtures or devices located in finished or unfinished areas, that are not required to have or are provided with finish color or coating shall be provided in a prime painted condition, ready to receive finish paint or coating. All galvanized metal in finished areas shall
be properly prepared with special processes to receive finish paint as directed and approved by the Architect.

40. INDEMNIFICATION

A. The Contractor shall hold harmless and indemnify the Engineer, employees, officers, agents and consultants from all claims, loss, damage, actions, causes of actions, expense and/or liability resulting from, brought for, or on account of any personal injury or property damage received or sustained by any person, persons, (including third parties), or any property growing out of, occurring, or attributable to any work performed under or related to this contract, resulting in whole or in part from the negligence of the Contractor, any subcontractor, any employee, agent or representative.

41. HAZARDOUS MATERIALS

A. The Contractor is hereby advised that it is possible that asbestos and/or other hazardous materials are or were present in this building(s). Any worker, occupant, visitor, inspector, etc., who encounters any material of whose content they are not certain shall promptly report the existence and location of that material to the Contractor and/or Owner. The Contractor shall, as a part of his work, insure that his workers are aware of this potential and what they are to do in the event of suspicion. He shall also keep uninformed persons from the premises during construction. Furthermore, the Contractor shall insure that no one comes near to or in contact with any such material or fumes therefore until its content can be ascertained to be non-hazardous.

B. CMTA, Inc., Consulting Engineers, have no expertise in the determination of the presence of hazardous materials. Therefore, no attempt has been made by them to identify the existence or location of any such material. Furthermore, CMTA nor any affiliate thereof will neither offer nor make any recommendations relative to the removal, handling or disposal of such material.

C. If the work interfaces, connects or relates in any way with or to existing components which contain or bear any hazardous material, asbestos being one, then, it shall be the Contractor's sole responsibility to contact the Owner and so advise him immediately.

D. The Contractor by execution of the contract for any work and/or by the accomplishment of any work thereby agrees to bring no claim relative to hazardous materials for negligence, breach of contract, indemnity, or any other such item against CMTA, its principals, employees, agents or consultants. Also, the Contractor further agrees to defend, indemnify and hold CMTA, its principals, employees, agents and consultants, harmless from any such related claims which may be brought by any subcontractors, suppliers or any other third parties.

42. ABOVE-CEILING AND FINAL PUNCH LISTS

A. The Contractor shall review each area and prepare a punch list for each of the subcontractors, as applicable, for at least two stages of the project:
(1) For review of above-ceiling work that will be concealed by tile or other materials well before substantial completion.

(2) For review of all other work as the project nears substantial completion.

B. When all work from the Contractor's punch list is complete at each of these stages and prior to completing ceiling installations (or at the final punch list stage), the Contractor shall request that the Engineer develop a punch list. This request is to be made in writing seven days prior to the proposed date. After all corrections have been made from the Engineer's punch list, the Contractor shall review and initial off on each item. This signed-off punch list shall be submitted to the Engineer. The Engineer shall return to the site once to review each punch list and all work prior to the ceilings being installed and at the final punch list review.

C. If additional visits are required by the Engineer to review work not completed by this review, the Engineer shall be reimbursed directly by the Contractor by check or money order (due net 10 days from date of each additional visit) at a rate of $140.00 per hour for extra trips required to complete either of the above-ceiling or final punch lists.
The following is CMTA’s guide for required electrical information relative to the Schedule of Values. Please utilize all items that pertain to this project and add any specialized system as required. A thorough and detailed schedule of values will allow for fair and equitable Pay Application approval and minimize any discrepancies as to the status of the job.

### Electrical

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## GENERAL PROVISIONS-ELECTRICAL

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END OF SECTION.
SECTION 16010 - SCOPE OF THE ELECTRICAL WORK

1. GENERAL

Each Electrical Contractor's attention is directed to Section 260501 - General Provisions, Electrical, and all other Contract Documents as they apply to his work.

2. SCOPE OF THE ELECTRICAL WORK

The Electrical work for this project includes all labor, materials, equipment, fixtures, excavation, backfill and related items required to completely install, test, verify place in service and deliver to the Owner complete electrical systems in accordance with the accompanying plans and all provisions of these specifications. This work shall primarily include, but is not limited to the following:

A. All conduits, conductors, outlet boxes, fittings, etc.
B. All switchgear, panels, disconnect switches, fuses, transformers, contactors, starters, etc.
C. Fault Current Coordination Study.
D. All wiring devices and device plates.
E. All light fixtures and lamps.
F. Emergency generator.
G. Electrical connection to all electrically operated equipment furnished and/or installed by others, including powered casework, kitchen equipment, etc.
H. Digital video surveillance system.
I. Security intrusion detection system.
J. Lightning protection system.
K. Voice/Data wiring system.
L. CATV wiring and distribution system.
M. Paging/Intercom distribution system.
N. Master clock distribution system.
O. Gym/Cafeteria/Auditorium Sound reinforcement system.
P. Fire alarm system.
Q. Wireless sound enhancement system.
R. Nurse call system.
S. Physiological monitoring system.

T. Theatrical lighting/dimming system.

U. All necessary coordination with electric utility company, telephone company, cable television company, etc. to insure that work, connections, etc., that they are to provide is accomplished and that service to this facility is delivered complete prior to occupancy.

V. Paying all necessary fees and cost for permits, inspections, work by utility companies (power, telephone, CATV, etc). The Contractor shall contact the utility companies prior to submitting a bid to determine exactly these charges will be.

W. Prior to submitting a bid, the Contractor shall contact all serving utility companies to determine exactly what each utility company will provide and exactly what is required of the Contractor and the Contractor shall include all such requirements in his base bid.

END OF SECTION.
SECTION 16015 - COORDINATION AMONG TRADES, SYSTEMS INTERFACING AND CONNECTION OF EQUIPMENT FURNISHED BY OTHERS

1. COORDINATION

A. The Contractor is expressly directed to read the General Conditions and all sections of these specifications for all other trades and to study all drawings applicable to his work, including Architectural, Plumbing, Fire Protection, Mechanical and Structural drawings, to the end that complete coordination between trades will be affected. Each Contractor shall make known to all other contractors the intended positioning of materials, raceways, supports, equipment and the intended order of his work. Coordinate all work with other trades and proceed with the installation in a manner that will not create delays for other trades or affect the Owner's operations.

B. Special attention to coordination shall be given to points where raceways, fixtures, etc., must cross other ducts or conduit, where lighting fixtures must be recessed in ceilings, and where fixtures, conduit and devices must recess into walls, soffits, columns, etc. It shall be the responsibility of each Contractor to leave the necessary room for other trades. No extra compensation or time will be allowed to cover the cost of removing fixtures, devices, conduit, ducts, etc. or equipment found encroaching on space required by others.

C. The Contractor shall be responsible for coordination with all trades to insure that they have made provision for connections, operational switches, disconnect switches, fused disconnects, etc., for electrically operated equipment provided under this or any other division of the specifications, or as called for on the drawings. Any connection, circuiting, disconnects, fuses, etc., that are required for equipment operation shall be provided as a part of this contract.

D. If any discrepancies occur between accompanying drawings and these specifications and drawings and specifications covering other trade's work, each trade shall report such discrepancies to the Architect far enough in advance so that a workable solution can be presented. No extra payment will be allowed for relocation of fixtures, devices, conduit, and equipment not installed or connected in accordance with the above instructions.

E. In all areas where air diffusers, devices, lighting fixtures and other ceiling-mounted devices are to be installed, the Mechanical Trade(s) and the Electrical Trade and the General Trades shall coordinate their respective construction and installations so as to provide a combined symmetrical arrangement that is acceptable to the Architect and Engineer. Where applicable, refer to reflected ceiling plans. Request layouts from the Architect or Engineer where in doubt about the potential acceptability of an installation.

2. INTERFACING

Each Electrical Trade, Specialty Controls Trade, Mechanical Trade and the General Trades, etc., shall insure that coordination is effected relative to interfacing of all systems. Some typical interface points are (but not necessarily all):
A. Connection of Telecommunications (voice, video, data) lines to Owner's existing or new services.

B. Connection of Power lines to Owner's existing or new services.

C. Connection of fuel oil and exhaust piping to emergency generator and furnishing of fuel for testing unit. Provide a full tank at final acceptance.

D. Connection of all controls to equipment.

E. Electrical power connections to electrically operated (or controlled) equipment.

F. Electrical provisions for all equipment provided by other trades or suppliers within this contract.

3. CONNECTION OF EQUIPMENT FURNISHED BY OTHERS

A. Each Contractor shall make all connections to equipment furnished by others, whenever such equipment is shown on any part of the drawings or mentioned in any part of the Specifications, unless otherwise specifically specified hereinafter.

B. All drawings are complementary, one trade of the other. It is the Contractor's responsibility to examine all drawings and specifications to determine the full scope of his work. The project Engineers have arranged the specifications and drawings in their given order solely as a convenience in organizing the project, and in no way shall they imply the assignment of work to specific trades, contractors, subcontractors or suppliers.

C. Supervision to assure proper installation, functioning and operation shall be provided by the Contractor furnishing the equipment or apparatus to be connected.

D. Items indicated on the drawings as rough-in only (RIO) will be connected by the equipment supplier or Owner, as indicated. The Contractor shall be responsible for rough-in provisions only as indicated. These rough-ins shall be in accord with the manufacturer's or supplier's requirements.

E. For items furnished by others, relocated, or RIO, the Contractor shall obtain from the supplier or shall field determine as appropriate, the exact rough-in locations and connection sizes for the referenced equipment.

F. The Contractor shall be responsible for coordinating with the General and all other trades, as necessary, to determine any and all final connections that he is to make to equipment furnished by others.

END OF SECTION.
SECTION 16020 - SHOP DRAWINGS, LITERATURE, MANUALS, PARTS LISTS, AND SPECIAL TOOLS

1. SHOP DRAWINGS

A. Each Contractor shall submit to the Architect and/or Engineer, within thirty days after the date of the Contract, seven sets of shop drawings and/or manufacturer's descriptive literature on all equipment required for the fulfillment of his contract. Each shop drawing and/or manufacturer's descriptive literature shall have proper notation indicated on it and shall be clearly referenced so the specifications, schedules, light fixture numbers, panel names and numbers, etc., so that the Architect and/or Engineer may readily determine the particular item the Contractor proposes to furnish. All data and information scheduled, noted or specified by hand shall be noted in color red on the submittals. The Contractor shall make any corrections or changes required and shall resubmit for final review as requested. Review of such drawings, descriptive literature and/or schedules shall not relieve the Contractor from responsibility for deviation from drawings or specifications unless they have, in writing, directed the reviewer's attention to such deviations at the time of submission of drawings, literature and manuals; nor shall it relieve them from responsibility for errors or omissions of any nature in shop drawings, literature and manuals. The term "as specified" will not be accepted.

B. If the Contractor fails to comply with the requirements set forth above, the Architect and/or Engineer shall have the option of selecting any or all items listed in the specifications or on the drawings, and the Contractor will be required to provide all materials in accordance with this list.

C. Review of shop drawings by the Engineer applies only to conformance with the design concept of the project and general compliance with the information given in the contract documents. In all cases, the installing Contractor alone shall be responsible for furnishing the proper quantity of equipment and/or materials required, for seeing that all equipment fits the available space in a satisfactory manner and that piping, electrical and all other connections are suitably located.

D. The Engineer's review of shop drawings, schedules or other required submittal data shall not relieve the Contractor from responsibility for the adaptability of the equipment or materials to the project, compliance with applicable codes, rules, regulations, information that pertains to fabrication and installation, dimensions and quantities, electrical characteristics, and coordination of the work with all other trades involved in this project.

E. No cutting, fitting, rough-in, connections, etc., shall be accomplished until reviewed equipment shop drawings are in the hands of the Contractors concerned. It shall be each Contractor's responsibility to obtain reviewed shop drawings and to make all connections, etc. in the neatest and most workmanlike manner possible. Each Contractor shall coordinate with all the other Contractors having any connections, roughing-in, etc., to the equipment, to
make certain proper fit, space coordination, voltage and phase relationships are accomplished.

F. In accord with the provisions specified hereinbefore, shop drawings, descriptive literature and schedules shall be submitted on each of the following indicated items as well as any equipment or systems deemed necessary by the Engineer:

Power Equipment

- Fault current coordination study (submit along with switchgear & panelboards).
- Switchgear and panelboards.
- Circuit breakers or fusible switches, per each type.
- Dry-type transformers.
- Liquid-filled pad-mount transformers and their accessories.
- Power and lighting contactors.
- Disconnect switches.
- Fuses, per each type required.
- Magnetic starters, if not submitted with unit equipment by supplier.
- Control components (relays, timers, selector switches, pilots, etc.)
- Primary cable (over 600 volts) and each style of termination fitting for primary cable.
- Building service grounding electrode components.
- Metering devices.
- Bus duct and each type of fitting for bus duct.
- Emergency generator, engine fuel system and transfer switch, with all required generator system accessories, such as battery charger, batteries, exhaust system and its insulation, fuel pumps, day tanks, etc.
- Lightning protection system.
- Transient voltage surge suppression system.
- Grounding system.

Raceways

- Cable tray and each type of cable tray fitting.
- Wireways and each type of wireway fitting.
- Surface-mounted metal or plastic raceways, with each type of fitting.
- J-hook or Bridle ring assemblies.

Devices

- Each type of wiring device and their coverplates.
- Floor boxes, each by type, with required accessories.
- Data/voice/video wallplates, each by type.
- Any special items not listed above.

Lighting
- Light fixtures, each by type, marked to indicate all required accessories and lamp selection. Also provide original color selection chart to allow Architect and/or Engineer to indicate color selection.
- Lamps, each by type.
- Ballast, each by type.
- Lighting standards or poles.
- Photocells, time clocks or other lighting accessories.
- Lighting control system schematic, functional & programming data, along with building specific floor plan drawings indicating each device, master controller, input device locations and specific interconnect/wiring requirements for each device.

Systems

Note: Each system submittal is to be complete with legible cutsheets for all devices, equipment, special wiring, etc. Include system specific wiring schematics showing each device and its specific interconnect/wiring requirements. For rack mounted equipment, provide a scalable elevation drawing with proposed component locations & specific interconnect wiring requirements for each component/panel. Also provide scale building specific layout drawings that indicate device placement, wiring, etc. Refer to the specific system's specification for additional submittal requirements where required.

- Fire alarm system.
- Closed circuit television security system.
- Intrusion detection system.
- Building paging/intercom audio system.
- Clock/program system.
- Telephone system.
- Video system.
- Data network.
- Sound reinforcement system(s).
- Wireless intercom system.

Miscellaneous

- Control panel assemblies.
- Non-standard junction/pullboxes.
- Manholes, hand holes, and all outdoor electrical equipment and fittings.

2. SPECIAL WRENCHES, TOOLS AND KEYS

A. Each Contractor shall provide, along with the equipment provided, any special wrenches or tools necessary to dismantle or service equipment or appliances installed by him. Wrenches shall include necessary keys, handles and operators for valves, switches, breakers, etc. and keys to electrical panels, emergency generators, alarm pull boxes and panels, etc. At least two of any such special wrench, keys, etc. shall be turned over to the Architect prior to
completion of the project. Obtain a receipt that this has been accomplished and forward a copy to the Engineer.

3. FIRE ALARM SHOP DRAWINGS

A. The Contractor and equipment supplier shall submit to the Architect and/or Engineer, fire alarm system shop drawings complete with catalog cuts, descriptive literature and complete system wiring diagrams for their review prior to the Contractor’s submittal to the Commonwealth's Department of Housing, Buildings and Construction or other governing authority for their review. No work shall be done until drawings are approved by the Kentucky Department of Housing, Buildings and Construction.

4. MAINTENANCE AND OPERATION MANUALS

A. Prior to substantial completion of the project, the Contractor shall deliver to the Engineers (in addition to the required Shop Drawings) three complete copies of operation and maintenance instructions and parts lists for all equipment provided. Formatting and content shall follow the guidelines outlined in the latest version of ASHRAE Application Handbook, Guideline 4. As a minimum, the following shall be included:

- The operation and maintenance document directory should provide easy access and be well organized and clearly identified.
- Emergency information should be immediately available during emergencies and should include emergency and staff and/or agency notification procedures.
- The operating manual should contain the following information:
  I. General Information
     a. Building function
     b. Building description
     c. Operating standards and logs
  II. Technical Information
     a. System description
     b. Operating routines and procedures
     c. Seasonal start-up and shutdown
     d. Special procedures
     e. Basic troubleshooting
- The maintenance manual should contain the following information:
  I. Equipment data sheets
     a. Operating and nameplate data
     b. Warranty
  II. Maintenance program information
     a. Manufacturer’s installation, operation, and maintenance instructions
     b. Spare parts information
     c. Preventive maintenance actions
d. Schedule of actions
e. Action description
f. History

- **Test reports** document observed performance during start-up and commissioning.

END OF SECTION.
SECTION 16030 - SLEEVING, CUTTING, PATCHING AND REPAIRING

1. GENERAL

A. The Contractor shall be responsible for all openings, sleeves, trenches, etc. that he may require in floors, roofs, ceilings, walls, etc. and shall coordinate all such work with the General Contractor and all other trades. He shall determine and coordinate any openings which he is to provide before submitting a bid proposal in order to avoid conflict and disagreement during construction. Improperly located openings shall be reworked at the expense of the responsible Contractor.

B. The Contractor shall plan his work ahead and shall place sleeves, frames or forms through all walls, floors and ceilings during the initial construction, where it is necessary for conduit, bus duct, conductors, wireways, etc. to go through; however, when this is not done, this Contractor shall do all cutting and patching required for the installation of his work, or he shall pay other trades for doing this work when so directed by the Architect. Any damage caused to the building by the workmen of the responsible Contractor must be corrected or rectified by him at his own expense.

C. The Contractor shall cut holes in casework, equipment panels, etc. (if any), as required to pass pipes in and out.

D. The Contractor shall notify other trades in due time where he will require openings of chases in new concrete or masonry. He shall set all concrete inserts and sleeves for his work. Failing to do this, he shall cut openings for his work and patch same as required at his own expense.

E. Openings in slabs and walls shall be cut with core drill. Hammer devices will not be permitted. Edges of trenches and large openings shall be scribe cut with a masonry saw.

F. Cast iron sleeves shall be installed through all walls where pipe enters the building below grade. Sleeves shall be flush with each face of the wall and shall be sufficiently larger than the entering pipe to permit thorough caulking with lead and oakum between pipe and sleeve for waterproofing.

G. In all cases, sleeves shall be at least two pipe sizes larger than nominal pipe diameter.

H. Sleeves passing through roof or exterior wall or where there is a possibility of water leakage and damage shall be caulked water tight for horizontal sleeves and flashed and counter-flashed with lead (4 lb.) or copper and soldered to the piping, lapped over sleeve and properly weather sealed. Any roof penetration shall not void or lessen the warranty in any way.

I. All rectangular or special shaped openings in plaster, stucco or similar materials including gypsum board shall be framed by means of plaster frames, casing beads, wood or metal angle members as required. The intent of this requirements is to provide smooth even termination of wall, floor and ceiling finishes as well as to provide a fastening means for lighting fixtures, panels, etc. Lintels shall be provided where indicated over all openings in bearing walls, etc.
J. No cutting is to be done at points or in a manner that will weaken the structure and unnecessary cutting must be avoided. If in doubt, contact the Architect.

K. The Contractor shall be responsible for properly shoring, bracing, supporting, etc. any existing and/or new construction to guard against cracking, settling, collapsing, displacing or weakening while openings are being made. Any damage occurring to the existing and/or new structures, due to failure to exercise proper precautions or due to action of the elements, shall be promptly and properly made good to the satisfaction of the Architect.

L. All work improperly done or not done at all as required by the Contractor will be performed by others. The cost of this work shall be paid for by the Contractor who is in non-compliance with the Contract.

2. SLEEVES, PLATES AND ESCUTCHEONS

A. The Contractor shall provide and locate all sleeves required for his work before the floors and surface being penetrated are built, otherwise the Contractor shall core drill for conduits where sleeves were not installed, or where incorrectly located. Core drilling is the only acceptable alternative to sleeves. Do not chisel openings. Where sleeves are placed in exterior walls or in slabs on grade, the space between the conduit and the sleeves shall be made completely and permanently watertight.

B. Conduits that penetrates fire and/or smoke rated assemblies shall have sleeves installed as required by the manufacturer of the rating seal used.

C. At all other locations either pipe sleeves or core drilled openings are acceptable.

D. Where thermal expansion does not occur, the wall may be sealed tight to the conduit.

E. Sleeves shall be constructed of 24 gauge galvanized sheet steel with lock seam joints or Schedule 40 pipe. Sleeves in floors shall extend 1" above finished floor level.

F. Fasten sleeves securely in floors, walls, so that they will not become displaced when concrete is poured or when other construction is built around them. Take precautions to prevent concrete, plaster or other materials being forced into the space between pipe and sleeve during construction.

G. In all areas where ducts are exposed and ducts pass thru floors, the opening shall be surrounded by a 4 inch high by 3 inch wide concrete curb.

H. Escutcheon plates shall be provided for all conduit passing thru walls, floors and ceilings. Plates shall be nickel plated, of the split ring type, of size to match the pipe or conduit. Where plates are provided for pipes passing thru sleeves which extend above the floor surface, provide deep recessed plates to conceal the sleeves.
I. When installing conduit, pipe, or any other work in insulated concrete form (ICF) walls, the responsible subcontractor for the work shall provide spray foam insulation to patch the rigid insulation to maintain full integrity of the insulating value of the wall after the mechanical and electrical work is complete. Furthermore all new work shall NOT be installed in concrete center of wall. All mechanical and electrical installations shall be on the interior side of the concrete.

END OF SECTION.
SECTION 16040 - EXCAVATION, TRENCHING, BACKFILLING AND GRADING

1. GENERAL

   A. Each Contractor's attention is directed to Section 260501, General Provisions, Electrical and all other contract documents as they may apply to his work.

   B. Each Contractor shall include all excavating, filling, grading and related items required to complete his work as shown on the drawings and specified herein.

   C. Electrical distribution lines and underground telephone or TV cables shall, in no case, be placed in the same trench with sanitary, storm, domestic or fire protection water lines. Phone cable may, at the Contractor's option, and if acceptable to both utility companies, be placed in a common trench with power lines as long as 8" of earth separation is maintained. T.V. cable shall, in all cases, be placed in a separate trench with two feet separation from electrical power lines.

   D. Depths of bury shall be as indicated on the drawings.

2. SUBSURFACE DATA

   A. Subsurface investigations have been made and the results shown on the drawings. The information was obtained primarily for use in preparing foundation design. Each Contractor may draw his own conclusions therefrom. No responsibility is assumed by the Owner for subsoil quality or conditions other than at the locations and at the time investigations were made. No claim for extra compensation, or for extension of time, will be allowed on account of subsurface conditions inconsistent with the data shown.

   B. Materials to be excavated shall be unclassified, and shall include earth, rock, or any other material encountered in the excavation to the depth and extent indicated on the drawings and specified herein. No adjustment in the Contract sum will be made on account of the presence or absence of rock, shale, or other materials encountered in the excavating.

3. BENCH MARKS AND MONUMENTS

   A. Maintain carefully all bench marks, monuments and other referenced points. If disturbed or destroyed, replace as directed.

4. EXCAVATION

   A. Each Contractor shall accept the site as he finds it and remove all trash, rubbish and material from the site prior to starting excavation for his work.

   B. Excavate trenches to sufficient width and depth for proper installation of the work and where required, smooth the bottom on the trench with hand tools.
C. The removal of rock shall be accomplished by use of hand or power tools only. Blasting shall not be permitted unless authorized in writing by the Architect. Any damage to existing structures, exterior services or rock intended for bearing, shall be corrected at the responsible Contractor's expense.

D. Keep trenches free from water while construction therein is in progress. Under no circumstances lay conduit or cable in water. Pumping or bailing water from this Contractor's trenches, which is required during construction shall be accomplished at his expense.

E. In no case shall excavation work be accomplished that will damage in any way the new structure, existing structures, equipment, etc. Each Contractor shall take the necessary steps to prevent flow of eroded earth by water or landslide onto the property of others, or against the structures. The repair of all such damage, or any other damage incurred in the course of excavation, shall be borne by the responsible Contractor.

5. BACKFILL

A. Backfill shall be accomplished with clean debris free earth and the new earth tamped at 12" intervals so as to avoid earth sinks along the trench. The responsible Contractor will be required to return to the project and fill any sunken areas along the route of his work.

B. Backfill trenches only after conduit and cable have been inspected, tested, and locations of pipe lines have been recorded on "as-built" drawings.

C. The backfill below paved areas shall be brought to proper grade to receive the sub-base and paving. No paving shall be placed on uncompacted fill.

D. The backfill below sodded or seeded areas shall be brought to within six inches of finished grade. The remaining six inches shall be backfilled with clean soil.

END OF SECTION.
SECTION 16060 - GROUNDING

1. GENERAL

A. All metallic conduit, raceways, cable trays, wireways, supports, cabinets and equipment shall be grounded in accordance with the latest issue of the National Electrical Code, as shown on the Contract Drawings and in accord with the requirements of the local authority having jurisdiction, as applicable.

B. The size of the equipment grounding conductors, grounding electrode conductors and service grounding conductors shall be not less than that given in Article No. 250 of the National Electrical Code, and/or as shown on the Contract Drawings. Where ungrounded conductor sizes are increased to minimize voltage drop, grounded conductor sizes shall be increased in the proper proportion.

C. Grounding bus and non-current carrying metallic parts of all equipment and raceway systems shall be securely grounded by connection to common ground.

D. The service entrance main ground bus shall also be connected to the main cold metallic water pipe within three feet of where it enters the building, on both the house and street sides of the main shut-off valve with a properly sized bonding jumper. A properly sized bonding jumper shall also be provided to the frame of any steel structure utilized in the construction. The steel frame of the building (if any) shall be made electrically continuous.

2. MATERIALS

A. Ground wires and cables shall be of the AWG sizes shown on the Contract Drawings or shall be sized in accord with the prevailing codes. All ground wires and cables shall be copper.

B. All grounding fittings shall be heavy cast bronze or copper of the mechanical type except for underground installations or interconnection of grounding grid to cable, columns and ground electrodes, which shall be thermically welded type as manufactured by Cadweld, Burndy Co., Therm-O-Weld, or approved equivalent. Other bonding clamps or fittings in above ground locations shall be as manufactured by O.A. Co., T & B, Burndy, or approved equivalent.

C. Ground electrode pipe systems shall be solid copper construction. Ground rods shall be 5/8" minimum diameter, eight feet long, copperweld steel. All ground electrode systems shall be installed in accord with manufacturer's recommendations, U.L. listings, National Electrical and National Electrical Safety Codes.

3. INSTALLATION

A. All grounding conductors shall be protected from mechanical injury and shall be rigidly supported. Where ground conductors are run through flexible conduit and through panelboard switchboard or motor control center feeders, they shall be securely bonded to such conduit thru
the use of grounding bushings at the entrance and exit. All connection of equipment shall be made with an approved type of solderless connection and same shall be bolted or clamped to equipment or conduit.

B. All equipment grounding conductors to lighting fixtures, devices, receptacles, electric heaters, furnace and other equipment not exceeding No. 8 AWG in size shall be green colored Type "THWN".

C. Equipment ground connections to GFI circuit breakers shall be carried and bonded to each outlet on the circuit. Provide a separate equipment grounding conductor with green color insulation.

D. Resistance to the grounding at the service entrance equipment shall be in accordance with the N.E.C. for style of construction and shall not exceed ten ohms as measured by the described testing method.

E. All circuits shall have a separate grounding conductor, except as otherwise noted.

F. When grounding systems are completely installed and all grading in the area of the service grounding electrode has been completed up to finish elevations, perform a fall-off potential or other approved test to determine actual system resistance to earth. Report results to the Engineer in writing. Refer to testing provisions in this section of specifications.

G. Where separately-derived systems are utilized as part of the power distribution network, the neutral leg of the secondary side of generators, transformers, etc., shall be connected to a grounding electrode in accordance with the manufacturer's recommendations.

H. The Contractor shall ensure that the ground return path thru building structural steel or other means is electrically continuous back to the service grounding electrode and is of adequate capacity and impedance to carry the maximum expected fault or other current. Where no electrically continuous steel building frame is available, the Contractor shall provide a properly sized ground bar and ground conductor routed back to the main facility ground bus.

I. Where a building's steel frame is made electrically discontinuous by masonry breaks (as at firewalls, etc.), the Contractor shall provide an accessible thermically welded bonding jumper of #500MCM copper to bond the building steel frame sections together, making the entire steel frame electrically continuous. The installation of these bonding jumpers shall be reviewed by the Engineer prior to their being covered by construction.

J. Where lightning protection systems are utilized on the work, their electrodes and conductors shall be electrically segregated from the building service ground, except where connections to structural elements are required for the proper installation of these systems. Lightning protection grounds shall only be utilized for lightning grounding applications, in accord with U.L. and manufacturer's recommendations.

K. Grounding connections shall never be made to fire protection, natural gas, flammable gas or liquid fuel piping, except where specifically indicated on the plans.
L. Where dielectric fittings are utilized in piping systems, the piping system shall **not** be utilized as a ground path. Bonding jumpers shall not be utilized to bridge over such fittings. Piping systems shall not be utilized as ground paths except where specifically required by codes in the case of water piping.

4. **GROUNDING ELECTRODE SYSTEM**

A. The ground electrode system shall be as specified herein. The system shall not require maintenance throughout the expected life span of the materials.

B. Ground system shall be an electrolytic rod type, as manufactured by Lyncole XIT Grounding, Superior Grounding Systems, L.E.C., Inc. (Chem-Rod), or approved equivalent. Electrode(s) shall be placed as shown on the plans, installed exactly per manufacturer's recommendations. Electrodes shall be installed vertically, 12 feet of overall length (or length as indicated), set in a drilled hole and backfilled per manufacturer's instructions with a special clay slurry surrounding the rod. Provide a concrete protection box with cast iron grate for the top of the rod termination. Ground system shall be per the following:

(1) Manufacturer: Lyncole XIT Grounding (or approved equivalent).
(2) Source: Lyncole XIT Grounding, 22412 S. Normandie Ave., Torrance, CA 90502  1-800-962-2610
(3) Shaft Configuration: Straight.
(4) Shaft Length: 12 feet (or as otherwise indicated).
(6) Material: Type K Copper.
(7) Construction: Hollow tube, 2.125" O.D., chemical filled with non-hazardous metallic salts.
(8) Weight 3.5 lbs. per foot of length, nominal.
(9) Ground Wire Termination: Exothermic ("Cadweld" by Contractor) connection to 4/0 conductor, with U-bolt with pressure plate provided as test point.
(10) Average Life Expectancy: 25 Years.
(11) Model Number: K2-(length)CS.
(12) Provide grounding system with the following components: protective box, backfill material. Box to be concrete with cast iron, tamper-resistant lid, backfill to be "Bentonite" clay.

C. Installation of Pipe Ground System

(1) **Pipe ground systems shall be installed exactly as required by the system manufacturer. The Contractor shall be diligent to observe the excavation, sealing tape removal, slurry backfill and all other critical requirements.**

(2) **Note: NEVER USE SAND OR ORDINARY EARTH AS A BACKFILL MATERIAL**

D. Pipe grounding system shall be warranted unconditionally by the Contractor for a period of one year from the date of substantial completion.
5. GROUND TESTING PROCEDURE

A. The actual resistance to earth of the service grounding electrode shall be measured by the Contractor via the fall-of-potential method. This testing shall be accomplished after the grounding electrode has been completely installed and the finished grade is achieved.

B. The results of the testing shall be summarized in a written report by the Contractor, which shall be forwarded to the Engineer for review. The report shall also be included with the operation and maintenance manuals for the Owner's information and future reference. This report is to also contain a detailed description and illustrations of the testing procedure, along with the name and model number of the testing instrument(s).

C. For the actual testing, the Contractor shall follow the procedures outlined below. A self-contained instrument such as a "Megger" or "Ground OHMMETER" shall be used that is designed to eliminate the influence of stray current effects on the accuracy of the measurements.

(1) Connect one side of the instrument to the grounding electrode conductor where it connects to the facility main ground bus (point C1). Disconnect and isolate the grounding electrode conductor for the test.

(2) Drive a copperweld reference electrode probe (point C2) into earth between 300 and 500 feet away from C1 and connect to measurement instrument.

(3) Drive the movable grounding probe (C3) into earth at ten equally spaced intervals, in a straight line between C1 and C2 points and note the E/I=R resistance readings on a graph at each point.

(4) The resistance measurements in OHMS taken from the flat part of the curve shall be averaged to determine the true grounding electrode resistance to earth.

(5) At completion of testing, remove reference electrode C2 and all temporary wiring and connections.

(6) If actual measurements of grounding electrode indicate a resistance greater than five OHMS, contact the Engineer for instructions. If deemed necessary by the Engineer, additional electrodes shall be placed and the measurement process repeated until the desired ground potential achieved.

END OF SECTION.
SECTION 16075 - IDENTIFICATIONS

1. GENERAL

A. Equipment, disconnect switches, motor starters, pushbutton stations, special device plates, and similar materials shall be clearly marked as to their function and use. Markings shall be applied neatly and conspicuously to the front of each item of equipment with 1/2" white laminacoid plate (or equivalent) with black letters 1/4" high.

B. The Contractor shall provide clearly legible typewritten directories in each electrical panel indicating the area, item of equipment, etc., controlled by each switch, breaker, fuse, etc. These directories are to be inserted into plastic card holders in each panel. The Contractor shall be required to demonstrate the accuracy of the panel directory for a random sampling of circuits in each panel board as directed in the field by the Engineer with corrections made immediately so it is imperative that care be taken during installation to insure 100% accurate directories.

C. All circuit breakers and disconnects serving fire alarm equipment shall be marked in red and clearly labeled as Fire Alarm Circuits.

D. Branch circuit panelboards and switchgear shall be provided with a white laminacoid plastic plate with 1/2" black letters for panel designation and 1/4" black letters showing voltage and feeder information. Branch circuit switches shall be designated as to function. Panelboard and switchgear labels shall indicate the source they are fed from, and the circuit number at that source. Panelboards shall also indicate color coding of the branch circuit phase conductors supplied. Clearly indicate the exact label legend to be furnished with each panelboard and switchgear on the shop drawings for each item of equipment prior to submission of shop drawings.

EXAMPLE:

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PANEL “XYZ”
FED FROM “MDP – 2”
120/ 208/ 3PH/ 4W – 225A
BLACK-RED-BLUE
CONDUCTORS
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E. Where branch circuit panelboards and switchgear are connected to an emergency source, the laminacoid plate shall be red, and the word "emergency" shall be incorporated into the legend. In healthcare applications, the NEC – designated branch (life safety, critical or equipment branch) shall also be incorporated into the legend, all in 1/4” letters. Also provide similar plates and legends for automatic transfer switches, and equipment disconnects 100 amps and larger.

F. Laminacoid plates shall be located at center of top of trim for branch circuit panels, switchgear, and centered at side for branch circuit switches. Fasten with self-tapping stainless steel screws or other approved method.
G. The building service disconnect(s) shall be marked with the maximum available fault current available at that location in accordance with NEC Article 110. If a fault current study is not required by this contract, the Contractor shall obtain fault current availability data from the utility company. This requirement applies to both new and existing services if any distribution equipment is changed.

END OF SECTION.
SECTION 16100 – VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

1. GENERAL

a. RELATED DOCUMENTS

1) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

b. SUMMARY

1) This Section includes the following:
   
   (a) Isolation pads.
   (b) Spring isolators.
   (c) Restrained spring isolators.
   (d) Channel support systems.
   (e) Restraint cables.
   (f) Hanger rod stiffeners.
   (g) Anchorage bushings and washers.

2) Related Sections include the following:

   (a) Division 26 Section "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

c. DEFINITIONS


3) OSHPD: Office of Statewide Health Planning and Development for the State of California.

d. PERFORMANCE REQUIREMENTS

1) Seismic-Restraint Loading:

   (a) Building Classification Risk Category is IV (2013 KBC – Table 1604.5).
   (b) Seismic Design Category: D.

      i) Component Importance Factor: 1.5.
e. ACTION SUBMITTALS

1) Product Data: For the following:
   a) Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   b) Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

   i) Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by agency acceptable to authorities having jurisdiction.
   ii) Annotate to indicate application of each product submitted and compliance with requirements.

c) Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.

2) Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

   a) Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.

   i) Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Division 26 Sections for equipment mounted outdoors.

   b) Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.

   c) Field-fabricated supports.

   d) Seismic-Restraint Details:

      i) Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.

      ii) Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events.

      iii) Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

f. INFORMATIONAL SUBMITTALS

1) Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.
2) Qualification Data: For professional engineer and testing agency.

3) Welding certificates.

4) Field quality-control test reports.

g. QUALITY ASSURANCE

1) Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

2) Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.


4) Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

5) Comply with NFPA 70.

6) Comply with ASCE.

2. PRODUCTS

a. VIBRATION ISOLATORS

1) Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

2) Manufacturers: Subject to compliance with requirements, provide products by one of the following:

3) Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

   (a) Ace Mountings Co., Inc.
   (b) Amber/Booth Company, Inc.
   (c) California Dynamics Corporation.
   (d) Isolation Technology, Inc.
(c) Kinetics Noise Control.
(f) Mason Industries.
(g) Vibration Eliminator Co., Inc.
(h) Vibration Isolation.
(i) Vibration Mountings & Controls, Inc.

4) Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

(a) Resilient Material: Oil- and water-resistant.

5) Spring Isolators: Freestanding, laterally stable, open-spring isolators.

(a) Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
(b) Minimum Additional Travel: 50 percent of the required deflection at rated load.
(c) Lateral Stiffness: More than 80 percent of rated vertical stiffness.
(d) Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
(e) Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
(f) Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

6) Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

(a) Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
(b) Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
(c) Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
(d) Minimum Additional Travel: 50 percent of the required deflection at rated load.
(e) Lateral Stiffness: More than 80 percent of rated vertical stiffness.
(f) Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

b. SEISMIC-RESTRAINT DEVICES

1) Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2) Manufacturers: Subject to compliance with requirements, provide products by one of the following:

3) Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   (a) Amber/Booth Company, Inc.
   (b) California Dynamics Corporation.
   (c) Cooper B-Line, Inc.; a division of Cooper Industries.
   (d) Hilti Inc.
   (e) Loos & Co.; Seismic Earthquake Division.
   (f) Mason Industries.
   (g) TOLCO Incorporated; a brand of NIBCO INC.
   (h) Unistrut; Tyco International, Ltd.

4) General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
   (a) Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

5) Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

6) Restraint Cables: ASTM A 603 galvanized or ASTM A 492 stainless-steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

7) Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod. Do not weld stiffeners to rods.

8) Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.

9) Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.

10) Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

11) Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
12) **Adhesive Anchor**: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

c. **FACTORY FINISHES**

1) **Finish**: Manufacturer's standard prime-coat finish ready for field painting.

2) **Finish**: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

   (a) Powder coating on springs and housings.
   (b) All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
   (c) Baked enamel or powder coat for metal components on isolators for interior use.
   (d) Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

3. **EXECUTION**

a. **EXAMINATION**

1) Examine areas and equipment to receive seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

2) Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

3) Proceed with installation only after unsatisfactory conditions have been corrected.

b. **APPLICATIONS**

1) **Multiple Raceways or Cables**: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

2) **Hanger Rod Stiffeners**: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

3) **Strength of Support and Seismic-Restraint Assemblies**: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.
c. SEISMIC-RESTRAINT DEVICE INSTALLATION

1) Equipment and Hanger Restraints:
   (a) Install restrained isolators on electrical equipment.
   (b) Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
   (c) Install seismic-restraint devices using methods approved an agency acceptable to authorities having jurisdiction providing required submittals for component.

2) Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

3) Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

4) Drilled-in Anchors:
   (a) Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   (b) Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   (c) Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   (d) Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
   (e) Set anchors to manufacturer's recommended torque, using a torque wrench.
   (f) Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

d. ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

1) Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

e. FIELD QUALITY CONTROL

1) Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
2) Perform tests and inspections.

3) Tests and Inspections:

   (a) Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
   
   (b) Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
   
   (c) Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
   
   (d) Test at least four of each type and size of installed anchors and fasteners selected by Architect.
   
   (e) Test to 90 percent of rated proof load of device.
   
   (f) Measure isolator restraint clearance.
   
   (g) Measure isolator deflection.
   
   (h) Verify snubber minimum clearances.
   
   (i) If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

4) Remove and replace malfunctioning units and retest as specified above.

5) Prepare test and inspection reports.

f. ADJUSTING

1) Adjust isolators after isolated equipment is at operating weight.

2) Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3) Adjust active height of spring isolators.

4) Adjust restraints to permit free movement of equipment within normal mode of operation.

g. SEISMI CONTROL FOR ELECTRICAL EQUIPMENT AND COMPONENTS

   (1) All electrical systems are to be seismically restrained. Equipment buried underground is excluded but entry of services through the foundation wall is included. Equipment referred to below is typical (equipment not listed is still included in this specification).

   (2) Raceways

   (3) Generator

   (4) Electrical panelboards, switchboards, cabinets, etc.
(5) Light Fixtures

END OF SECTION.
SECTION 16120 - CONDUCTORS, IDENTIFICATION, SPLICING DEVICES & CONNECTORS

1. GENERAL

   A. This section of the Specifications covers all of the electrical power, lighting, and control power (line voltage) conductors, but does not include communications, data or signal system conductors, which are specified separately in these specifications.

   B. All conduits installed without conductors shall have a 200 lb. test nylon string installed for future use, tied off securely at each end.

   C. No more than 40% conduit fill is permitted for any conduit system, including video, intercom, data, power or other signal circuits unless specifically indicated otherwise on the plans.

   D. Lighting circuits: No more than five conductors shall be installed in conduit except for switch legs and travelers in multi-point switching arrangements.

   E. Receptacle circuits: If multiple circuits are pulled in a single homerun, a dedicated neutral shall be provided for each phase conductor. In these cases, a maximum of seven conductors are permitted in a single conduit. Conductors shall be derated per N.E.C.

   F. Intentional or unintentional painting of exposed low voltage or line voltage cabling is prohibited. The contractor shall ensure that exposed cabling is adequately protected from direct painting or overspray whether painting is required within the electrical specifications or required by other disciplines/trades. The contractor shall review the painting requirements for all disciplines and shall provide cabling protection as required. Where exposed cabling is being installed in exposed ceiling or wall spaces that are required to be painted, the contractor shall provide alternate options for cable colors and shall provide submittals for such cabling to engineer for approval.

2. MATERIALS

   A. CONDUCTORS

      (1) All conductors shall be 98% conductive annealed copper unless otherwise noted, UL listed and labeled.

      (2) Lighting and receptacle branch circuits shall be not less than No. 12 copper wire or of the sizes shown on the drawings with Type THW, THHN or THWN insulation. All feeder circuits shall be Type THW or THWN of the size as shown on the Contract Drawings. THHN wiring shall only be installed in overhead, dry or damp locations. THWN or THW wiring shall be used for all circuits pulled in underground or other wet locations.

      (3) Conductors No. 10 and smaller sizes of wire shall be solid. Conductors No. 8 and larger sizes shall be stranded.
(4) Conductors for fire alarm wiring shall be stranded and in full compliance with N.E.C. 760. All fire alarm conductors shall be installed within conduit and enclosed junction boxes.

(5) All wire on the project shall be new, in good condition, and shall be delivered in standard coils or reels.

(6) The color of the wire shall be selected to conform with Section 210-5 of the latest edition of the National Electrical Code. Refer also to 260519-4, Color Coding.

(7) All equipment grounding conductors shall have green color insulation or if larger than #8, shall be taped for two inches, green color at every termination and pullbox access point.

(8) Conductors used for motor connections and connections to vibrating or oscillating equipment shall be extra flexible.

(9) Conductors for main ground from neutral bus, equipment grounding bus, building steel, grounding grid and main cold water pipe connection shall be bare copper.

(10) All conductors shall be identified by color code and by means of labels placed on conductors in all junction boxes and at each terminal point with Brady, Ideal, T & B or approved equivalent labels indicating source, circuit No. or terminal No.

(11) Branch wiring and feeder conductors that are greater than 100' in length shall be increased at least one size to compensate for voltage drop. All circuits shall be installed and sized for a maximum 2% voltage drop. As calculated using 80% of the supply breaker rating as the load. Adjust conductors and conduit size accordingly for actual field installed conditions.

B. SPLICING DEVICES & CONNECTORS

(1) Splicing devices for use on No. 14 to No. 10 AWG conductors shall be pressure type such as T & B "STA-KON", Burndy, Reliable or approved equivalent.

(2) Wire nuts shall be spring pressure type, insulation 600V, 105°C insulation, up to #8 size. Greater than #6 Cu shall be a compression type connection, 600V insulation, cold shrink tubing, taped to restore full insulation value of the wire being spliced.

(3) Pressure crimp-applied ring type (or fork with upturned ends) terminations shall be employed on motor and equipment terminals where such terminals are provided on motor and equipment leads or on all stranded wire terminations using No. 10 AWG or smaller conductors.

(4) Splices, where necessary, shall be made with hydraulically-set "Hy-press" or equivalent crimped connectors. All splices shall be insulated to the full value of the wiring insulation using a cold-shrink kit or the equivalent in built-up materials.
(5) Large connectors (lugs) at terminals shall be mechanical type, hex-head socket or crimp-on style, installed per the manufacturer's recommendations.

(6) Exterior underground connections made between bare ground wires or to ground rods shall be exothermically welded, "Cadweld" or equivalent.

(7) The use of split-bolt clamps will be permitted in wireways at service entrance only. Torque to 55 foot-pounds or as recommended by manufacturer.

(8) No aluminum conductors shall be used.

3. INSTALLATION

A. The pulling of all wires and cable on this project shall be performed in strict compliance with applicable sections of the National Electrical Code. No conductor entering or leaving a cabinet or box shall be deflected in such a manner as to cause excess pressure on the conductor insulation. Conductors shall only be installed after insulating bushings are in place.

B. The radius of bending of conductors shall be not less than eighteen times the outside diameter of the conductor insulation or more, if recommended by the manufacturer.

C. Conductors installed within environmental air plenums shall be per N.E.C. Article 800 and other applicable codes, with FEP-type insulation or an approved equivalent. Also provide plenum-rated tie-wraps where plastic straps or other supports, etc., are installed in plenum areas.

D. Where indicated, communications conductors that are installed exposed shall not be routed across ceilings or ductwork. They shall be held up against building structure or against permanent support members. They shall be installed in such a manner that they do not interfere with the access to or operation of equipment or removal of ceiling tiles. Tie-wraps shall be installed in such a manner so as to bundle conductors neatly, allowing runouts of single conductors or groups to drop down to equipment served. Install grommeting where dropping out of trays or into panels or service columns. Install sleeves with bushings where penetrating partitions. Firestop sleeves with approved material. Do not penetrate firewalls if so indicated on plans. Refer to the drawings for support requirements and details on routing exposed communications conductors.

E. Conductors for isolated power systems shall be installed in as short a run of conduit as practicable. No pulling soap shall be used on conductors in isolated power systems.

F. Where conductors are installed in industrial facilities, they shall be per J.I.C. standards.

G. Maximum permissible pulling tensions, as recommended by the manufacturer for any given type of cable or wire installed shall not be exceeded. Utilize special remote readout equipment as required to ensure compliance. Use particular caution when installing twisted pair data cable or fiber optic cables -- forces permitted for pulling in are typically very low for these cable types.
H. All cables and wiring, regardless of voltage, installed in manholes or cable vaults shall be routed in such a manner to provide a minimum of 6 feet of slack cable for future splicing. Install cables along walls by utilizing the longer route from entry to exit. If both routes are symmetrical, provide a loop of cable secured to wall. All cables shall be tied to insulated cable supports on wall-mounted racks, spaced a maximum of three feet apart.

I. Where multiwire branch circuits are allowed the phases and neutral shall be wire-tied together in the panelboard and in all pull boxes.

4. COLOR CODING DISTRIBUTION VOLTAGE CONDUCTORS, 600 VOLT OR LESS

A. Conductors to be color coded as follows:

(1) 120/208 Volt Conductors
   Phase A - Black
   Phase B - Red
   Phase C - Blue
   Neutral - Solid White or White with tracer stripe to match phase conductor

(2) 277/480 Volt Conductors
   Phase A - Brown
   Phase B - Orange
   Phase C - Yellow
   Neutral – Solid Gray or White with tracer stripe to match phase conductor

(3) Isolated Power Conductors (Type XLP or XHHN)
   Phase A – Brown with colored stripe other than white, green or grey
   Phase B Device or Neutral - Orange with colored stripe other than white, green or grey
   Phase C - Yellow with colored stripe other than white, green or grey
   Neutral on Three-Phase Systems - Solid White or White with tracer stripe to match phase conductor

Note: Further identify isolated power conductors with 2" wide purple tape at all terminations and junctions.

(4) Control Wiring - Red, or as indicated.

(5) Conductors within enclosures that may be energized when enclosure disconnect is off - yellow, or taped with 1/2" yellow tape every 6" of length, inside enclosure. Provide lamacoid plate warning sign on front of enclosure where this condition occurs.

(6) D.C. Wiring - Positive - Light Blue
    Negative - Dark Blue

5. COMMUNICATIONS CONDUCTORS
A. Communications conductors shall be of type suitable for the service, installed in accordance with the manufacturer's recommendations for pulling tensions, support, terminations, proximity to high power fields, etc. Types not indicated on this schedule but indicated on plans shall be as noted or required for the service. If in doubt, contact the Engineer for clarification.

B. Plenum-rated conductors (per N.E.C.) shall be installed where required by codes. If installation is thru an approved raceway system that excludes the wiring from the plenum, non-plenum type may be used.

C. All communications cables shall be furnished and installed in compliance with U.L. 444, U.L. 13, N.E.C. 800, 725, 760 and all applicable codes and standards, for premises or riser installations.

D. Riser cables shall be provided in accord with current edition of the N.E. Code.

E. Schedule of Wiring Types - Plenum-Rated

<table>
<thead>
<tr>
<th>Data Circuits</th>
<th>24 AWG, 4 Pair</th>
<th>Anixter #CMP-00424 FAS-5B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Certified Category Five</td>
<td></td>
</tr>
<tr>
<td></td>
<td>U.T.P. Plenum-Rated</td>
<td>Belden Equivalent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Berk-Tek Equivalent</td>
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<td></td>
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<td>A.T.&amp;T. Equivalent</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Voice Circuits</th>
<th>24 AWG, 4 Pair</th>
<th>Anixter #CMP-00424 FAS-5B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td>A.T.&amp;T. Equivalent</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Voice Circuits</th>
<th>24 AWG, 4 Pair</th>
<th>Anixter #CMP-00422 HAH-3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Certified Category Three</td>
<td></td>
</tr>
<tr>
<td></td>
<td>U.T.P. Plenum-Rated</td>
<td>Belden Equivalent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>W.P.W. Equivalent</td>
</tr>
</tbody>
</table>

| Video Drops                   | RG-6/U Coaxial,                   | Belden #89120                  |
|-------------------------------| 18 AWG Solid Conductor,           | Anixter Equivalent             |
|                               | Plenum-Rated                      | Berk-Tek Equivalent            |

| Video Trunks                  | RG-11/U Coaxial,                  | Belden #89292                  |
|-------------------------------| 14 AWG Solid Conductor,           | Anixter Equivalent             |
|                               | Plenum-Rated                      | Berk-Tek Equivalent            |

| T-1 Premises Extension Cable  | T-1, 4 Pair 22 AWG,               | Anixter #CMP-00422T1-3         |
|-------------------------------| Plenum-Rated                      | Belden Equivalent              |
|                               | Pairs Individually Shielded       | Berk-Tek Equivalent            |

| 12-Strand Fiber (or # of Strands as Noted) | Multimode 62.5/125 Micron, Plenum-Rated | Anixter #370-949-FDDI-12 Siecor Equivalent Berk-Tek Equivalent |
### Speaker Cable
- 22 AWG, 1 Pair Shielded
- Belden #88761
- W.P.W. Equivalent
- Anixter Equivalent

### Speaker Cable, with Call-In Unshielded Pair
- 22 AWG, 1 Pair Shielded, 1 Pair 22 AWG. Unshielded
- Belden #88723
- W.P.W. Equivalent
- Anixter Equivalent

### 100 Pair Telephone Cable
- 24 AWG, 100 Pairs, Non-Plenum Exchange Cable, Wet Location Rated, Gel-Filled Certified Category Three
- Anixter #E-010024DFC
- Belden Equivalent
- A.T.&T. Equivalent

### F. Schedule of Wiring Types - Non-Plenum Rated

<table>
<thead>
<tr>
<th>Data Circuits</th>
<th>24 AWG, 4 Pair Certified Category Five U.T.P.</th>
<th>Anixter #CM-00424 CAG-5B Belden Equivalent Berk-Tek Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice Circuits</td>
<td>24 AWG, 4 Pair Certified Category Five U.T.P.</td>
<td>Anixter #CM-00424 CAG-5B Belden Equivalent Berk-Tek Equivalent</td>
</tr>
<tr>
<td>Voice Circuits</td>
<td>24 AWG, 4 Pair Category Three U.T.P.</td>
<td>Anixter #CM-00422 BAG-3 Belden Equivalent W.P.W. Equivalent</td>
</tr>
<tr>
<td>Video Drops</td>
<td>RG-6/U Coaxial 18 AWG Solid Conductor</td>
<td>Belden #9060 Anixter Equivalent W.P.W. Equivalent</td>
</tr>
<tr>
<td>Video Trunks</td>
<td>RG-11/U Coaxial, 14 AWG Solid Conductor</td>
<td>Belden #1523A Anixter Equivalent W.P.W. Equivalent</td>
</tr>
<tr>
<td>T-1 Premises Extension Cable</td>
<td>T-1, 4 Pair 22 AWG, Pairs Individually Shielded</td>
<td>Anixter #CM-00422 MIGT-3 Belden Equivalent Berk-Tek Equivalent</td>
</tr>
<tr>
<td>12-Strand Fiber (or # of Strands as Noted)</td>
<td>Multimode 62.5/125 Micron</td>
<td>Anixter #370-647-FDDI-12 Siecor Equivalent Berk-Tek Equivalent</td>
</tr>
<tr>
<td>Speaker Cable</td>
<td>22 AWG. 1 Pair Shielded, Plenum-Rated, Stranded</td>
<td>Belden #9414 Equivalent W.P.W. or Anixter</td>
</tr>
<tr>
<td>Speaker Cable with Call-In Pair</td>
<td>22 AWG. 1 Pair Shielded, 1 Pair 22 AWG. Unshielded for Call-In, Plenum-Rated</td>
<td>Belden #8730 W.P.W. Equivalent Anixter Equivalent</td>
</tr>
<tr>
<td>100 Pair Telephone Cable</td>
<td>24 AWG. 100 Pairs, Non-Plenum Exchange Cable, Wet Location Rated, Gel-Filled, Certified Category Three, Installed in Metal Conduit</td>
<td>Anixter #E-010024DFC Belden Equivalent A.T.&amp;T. Equivalent</td>
</tr>
</tbody>
</table>

6. HIGH VOLTAGE PRIMARY CABLE

A. High voltage primary cable shall be rated for aerial, direct burial, open tray, wet location and submersible underground service. Cable shall be I.P.C.E.A. - listed and UL listed for the use indicated.

B. Cable shall be rated 15 K.V., nominal. Insulation shall be XLP, XLPE or approved equivalent with a nominal 133% value.

C. Cable shall be shielded, grounded, with extruded 8 mil. semiconducting layer bonded to the insulation. Provide with copper drain wires served over semiconducting layer.

D. Cable shall be installed in accordance with manufacturer's recommendations, with particular attention to termination, handling, bending radii and pull tension recommendations.

E. The conductor shall be copper with Class "B" stranding per ASTM B-8.

F. Cable shall be as manufactured by G.E., Anaconda, Phelps-Dodge, Okonite, or approved equivalent.

G. Cable shall be manufactured per the following standards: UL 1072 and ICEA for medium voltage cable.

H. (1) Cable shall be terminated at pad-mount transformer or as indicated with pre-manufactured load-break, dead-front elbows and fittings compatible with cable and rated for the purpose. Pre-manufactured elbows and other types of fittings indicated shall be as manufactured by Elastimold Co., Blackburn-ITT, R.T.E. Corporation, S & C Company or other approved equivalent.

(2) Cable terminators for 15 K.V., 200 ampere connection shall be ANSI Standard 386-1877 200 amp hot-stick operable load break elbow with voltage test point. The elbow shall be furnished with the necessary cable adapter for terminating the copper cable used.
(3) Electrical ratings shall be as follows:

Voltage .....................................................................................................................15 KV class
Continuous and Load Break Current .................................................................200 amps, rms
BIL .......................................................................................................................... 95 KV
Withstand Voltage (AC) ........................................................................34 KV, 60 Hz, 1 minute
Short-Time Current ..................................................................................10,000 amps, rms, sym., 17 seconds.

(4) Cable terminators for 15 K.V., 600 ampere connection shall be ANSI Standard 368-1977 premolded dead break unit for terminating 15 KV shielded cable. The connector shall be fully shielded, of dead front operation and shall be fully submersible. The connector shall be furnished with proper adapters for terminating the copper cable used.

(5) The connectors shall have the following ratings:

Voltage ....................................................................................................................15 KV Class
Continuous Current ..................................................................................600 amps, rms
BIL .......................................................................................................................... 95 KV
8 Hour Overload ........................................................................................ 900 amps, rms
Withstand Voltage (AC) ........................................................................35 KV, 60 Hz, 1 minute
Momentary ..................................................................................25,000 amps, rms, sym., 17 seconds

I. Cable shall be color coded at all terminations and junctions as follows:

Phase A - Black
Phase B - Red
Phase C - Blue

Follow the above color coding unless otherwise indicated or required by system user.

J. Cable grounding at all terminations shall be in accord with the manufacturer's recommendations and applicable codes.

K. A full size (matching phase conductors) copper 600 volt insulated ground is to be provided with each primary circuit.

L. Installation, termination and testing of primary power cables shall be accomplished by Journeymen Electricians with at least three years experience with such work.

M. In lieu of using pre-manufactured elbows and other fittings, installer may substitute field-build and taped stress cones or other type of termination, subject to written prior approval of the engineer. In requesting such approval, submit complete data on materials proposed to be used and tools to be used in cutting and stripping cable.

N. All new primary cable shall be high-potential tested in accord with criteria outlined herein. Where taps, splices or terminations to existing primary cables are indicated on the plans, the
Engineer reserves the right to request high-potential testing of the existing cable or systems to determine their suitability and safety, if not so indicated on the plans.

O. Always field verify exact primary power voltage potentials with the supplying utility and report any discrepancy from that indicated on the plans to the Engineer prior to placing any primary cable in service.

7. TESTING OF PRIMARY CABLE

A. All new primary cable shall be tested prior to energization in accord with the following criteria, or other approved method.

(1) Use equipment made by one of the following (or approved equivalent) and abide by their operation rules for their respective equipment:

   a. Associated Research, Inc.
   b. J.G. Biddle Company
   c. Hipotronics, Inc.
   d. Von Corporation

(2) Clear cable of all equipment, switchgear, etc. for elbows, install insulation plugs. On cable end, insulate by high voltage taping, insulating jar or plastic. All terminations and splices shall be completely and properly grounded. All adjacent equipment shall be grounded, where danger of flashover exists.

(3) A sphere gap in parallel with the 100,000 volt D.C. "Hipot" tester shall be calibrated for sparkover at 70 KV D.C.

(4) The direct current test voltage shall be applied in increments of 5 KV and shall be left at the step for 1 minute. Saturate cable for 15 minutes at test voltage as in (5) below.

(5) Test: (as appropriate)

   a. 15 KV cables with open terminations at 55 KV D.C.
   b. 15 KV cables with elbow termination at 45 KV D.C., or to the limit of the elbow or splice. Verify with manufacturer.

   SPECIAL NOTE: It is suggested that tests be performed when relative humidity is 50 to 60% or less in clear, dry weather for greater safety.

(6) Record the leakage current at each step and at end of saturation time.

(7) Acceptance: The above procedure with less than 100 microamperes of current registered.

(8) Proof test on existing cable at 35 KV for 5a and 35 KV for 5b above.
(9) After test (in order listed):

a. Turn tester power off.
   b. Discharge tester and cable thru a resistive discharge device (8 MEGOHM discharge stick).
   c. Ground cable thru a grounding means (#12 AWG THW wire to ground).
   d. Disconnect tester.

(10) For Safety:

a. Wear high voltage gloves at all times.
   b. Treat cable and tester as high voltage at all times.
   c. Remember, D.C. static charges can be very harmful.

(11) All tests must be made in the presence of the Engineer and shall be recorded on a form sheet signed by the person performing the test and dated. Three (3) copies shall be submitted to the Engineer. Provide 48 hour advance written notice to Engineer.

END OF SECTION.
1. GENERAL

A. This section is intended to specify the raceways, conduit, conduit fittings, hangers, junction boxes, splice boxes, specialties and related items necessary to complete the work as shown on the drawings and specified herein.

B. This section specifies basic materials and methods and is a part of each Division 16 that implies or refers to electrical raceways specified therein.

C. The types of raceways specified in this section include the following:

   (1) Steel electrical metallic tubing. (E.M.T.)
   (2) Rigid galvanized steel conduit. (G.R.S.)
   (3) Intermediate metal conduit (I.M.C.).
   (4) Rigid aluminum conduit.
   (5) Flexible metal conduit (aluminum or steel)
   (6) Liquid - tight flexible metal conduit.
   (7) Rigid nonmetallic conduit.
   (8) Surface metal raceways.
   (9) Wireways, wall ducts and trench ducts.
   (10) Cable tray or cable trough.
   (11) Duct banks, and their construction.

D. All raceways, as listed in 1C. above and otherwise specified herein shall be provided in compliance with latest editions of all applicable U.L., NEMA, N.E.C. and A.N.S.I. standards. All conduit, raceways and fittings shall be Underwriters Laboratories listed and labeled, or bear the listing of an agency acceptable to the local authority having jurisdiction.

E. Conduit and raceways, as well as supporting inserts in contact with or enclosed in concrete shall comply with the latest edition of all A.C.I. standards and the equipment manufacturer's recommendations for such work.

F. P.V.C. or other non-metallic conduit shall be rated for the maximum operating temperature that could be developed by the conductors it encloses, while in normal operation.

G. The decision of the Engineer shall be final and binding in any case where a question or inquiry arises regarding the suitability of a particular installation or application of raceways, supports or materials, if other than outlined herein.

H. Minimum size of conduit shall be 3/4" trade size. All conduit and raceways shall be sized for the number of conductors contained, in accord with the latest edition of the National Electrical Code or any other applicable standards.
I. The installer of raceway systems shall avoid the use of dissimilar metals within raceway installations that would result in galvanic-action corrosion.

2. MATERIALS

A. STEEL ELECTRICAL METALLIC TUBING

(1) Electrical metallic tubing, (E.M.T.) of corrosion-resistant steel construction shall be permitted for concealed installation in dry interior locations. Electrical metallic tubing shall not be installed in concrete slabs or where exposed to physical damage. Electrical metallic tubing shall be permitted for exposed work in mechanical and electrical rooms and other exposed structure areas where not subjected to physical damage, as determined by the Engineer.

B. RIGID GALVANIZED STEEL CONDUIT

(1) Rigid galvanized steel conduit shall be used where subject to physical damage for exposed work in mechanical spaces, within factory or other industrial work areas, for exposed fit-up work on machinery, for exposed exterior damp or wet location work, in hazardous atmospheres, in exterior underground locations where installed beneath roadways, where ells occur in underground P.V.C. conduits, or where turning out of concrete encased duct banks, and at other locations as specifically called out on the drawings.

(2) Rigid galvanized steel conduit shall be used for all building interior power wiring or cables of over 600 Volts.

C. INTERMEDIATE METAL CONDUIT

(1) Unless otherwise indicated on the drawings, intermediate metal conduit (I.M.C.) may be used in any location in place of rigid galvanized steel conduit, as permitted by codes, and as approved by the Engineer.

D. RIGID ALUMINUM CONDUIT

(1) Rigid aluminum conduit, shall be permitted for installation indoors in dry locations only. Under no conditions shall it be cast into concrete slabs or pass thru construction where prolonged contact will degrade the aluminum. All ells used in rigid aluminum conduit systems shall be rigid galvanized steel. Rigid aluminum conduit shall always be used for power wiring greater than 5 KVA and higher than 60 Hz frequency.

E. FLEXIBLE METAL CONDUIT

(1) Flexible conduit shall be used where permitted by NEC. It may be constructed of aluminum or steel. It shall be installed with connectors designed for the purpose. All flexible metal conduit shall be installed as a single piece. No joints shall be installed. Flexible conduit shall not be used in wet or dusty locations or where exposed to oil, water or other damaging
environments. An equipment grounding conductor or bonding jumper shall be used at all flexible conduit installations. Maximum permitted length of flexible metal conduit shall be 72", as for light fixture whips unless approved in writing by Engineer.

F. LIQUIDTIGHT FLEXIBLE METAL CONDUIT

(1) Weatherproof flexible metal conduit shall be wound from a single strip of steel, neoprene covered, equivalent to "Liquatite" or "Sealtite" Type "UA". It shall be installed in such a manner that it will not tend to pull away from the connectors. Provide strain relief fittings equivalent to "Kellems" as required where subject to vibration. Flexible connections to motors in dusty areas shall be dust-tight, in areas exposed to the weather - weatherproof.

G. RIGID NON-METALLIC CONDUIT

(1) Rigid non metallic conduit shall be constructed of P.V.C, nominally schedule 40 weight, except where encased in concrete, where it may be "EB" type. If installation will enclose utility company provided conductors, verify exact type required and install in accord with their standards, if more stringent than this specification.

(2) Rigid non-metallic conduit may be used in exterior wet or damp locations where installed underslab or underground. It shall not be run in interior locations, except with special permission from the Engineer for use in corrosive environments, and then only if protected from physical damage. No rigid nonmetallic conduit may be installed in environmental air plenums or cast into above-grade concrete slabs. No rigid nonmetallic conduit may be installed in locations where the ambient temperature might exceed the rating of the raceway.

(3) Where rigid non metallic conduit is placed underground, as for feeder circuits, secondaries or branch circuit runs and where ell is made upward thru a slab on grade, transition the turning ell and the riser to rigid steel conduit to a height of 6" above the concrete slab. Transition may then be made to E.M.T or other approved conduit for remainder of run.

(4) Flexible nonmetallic conduit shall not be used, except by special permission, obtained in writing from the Engineer.

(5) Provide equipment grounding conductors of copper, sized as required by codes, in all circuits installed in rigid nonmetallic raceways.

H. SURFACE METAL RACEWAYS

(1) Surface metal raceways shall be constructed of code gauge corrosion-resistant galvanized steel or aluminum extrusions, and finished in an ivory, buff or grey color as selected by the Architect. Finishes shall be suitable for field painting, prepared by the installing contractor as necessary.
(2) Surface metal raceways, where used as raceways only, shall be sized for the conductors indicated. Nominal minimum size of such raceways shall be equivalent to Wiremold Co. Series #700, or equivalent by Isotrol or other approved manufacturer.

(3) Surface metal raceways to be furnished with integral receptacles shall have Simplex Nema 5-20R outlets spaced on centers as indicated on plans. These shall be Wiremold Co. #2200 Series or equivalent Isotrol or other approved manufacturer.

(4) Surface metal raceways and all components and fittings shall be furnished by a single manufacturer, wherever practical. All trim and cover fittings, flush feed boxes, splices, outlet fittings, etc, necessary for a complete installation shall be provided by the installing contractor. These raceways shall be rigidly mounted with approved fasteners on not to exceed 24" centers in a run, or 6" from ends and on either side of a corner. Refer to plans for notations on exact types of these raceways and outlet configurations.

I. WIREWAYS, WALL DUCT, FLUSH FLOOR TRENCH DUCT

(1) WIREWAYS

a. Wireways of painted steel construction shall be corrosion-resistant, moisture and oil resistant where indicated or necessary. Wireways shall be furnished in nominal sizes of 2 1/2" X 2 1/2", 4" X 4", 6" X 6", 8" X 8" or 12" X 12", as indicated on plans. Furnish with hinged covers on all runs and removable covers on all fittings, to allow a continuous unobstructed path for conductor installation. Provide knockouts on all runs, unless otherwise indicated or prohibited by codes.

b. Provide wireways with hangers of same manufacturer, installed so as to allow unobstructed access to wireway interior. Install at not to exceed 8'-0" centers, closer as needed at fittings and turns. Use 1/4" rod hangers minimum for up to 4"X4", 3/8" rod minimum up to 8"X8", 1/2" rod minimum for 12" X 12".

c. Wireways shall be equivalent to Square "D" Co. "LD" series, as a minimum standard of construction and quality.

(2) WALL DUCTS

a. Where wall duct type raceways are indicated to be installed flush, they shall be a minimum 3 1/2" deep by 10" wide (or 18" width, as indicated), furnished with screw covers to overlap flange 1" on each side. Covers shall be furnished in nominal 3'-0" lengths. Provide fully grommeted openings or bushed nipples as needed in coverplates to pass cables thru. Where indicated or required, provide transition fittings between horizontal runs of wireway and wall ducts to properly interface each raceway system.

b. Where wall ducts are installed flush either vertically or horizontally as a collector duct, provide proper blocking and support in stud walls, adding a layer of studs as needed to
prevent undercutting major structural elements of walls. Trim flange shall be set tight to wall surface with 1/16" tolerance each way.

c. Wall ducts, if indicated to be surface mounted, shall be furnished with flangeless coverplates.

d. All completed systems shall be provided with a factory prime painted finish, suitable for field finish painting.

e. Wall ducts shall be equivalent to Square D Company "RWT" Series, as a standard of construction and quality.

(3) TRENCH DUCTS

a. Trench duct is to be installed flush with finished concrete floor slab with a vertical tolerance to adjacent surfaces of 1/16" plus or minus. Nominal depth of trench duct shall be adjustable from 2 3/8" to 3 1/2", minimum 12" width unless otherwise noted on plans.

b. Trench duct shall be constructed of code-gauge steel, 14 gauge minimum, with corrosion resistant finish. Surfaces of duct or fittings in contact with concrete shall be painted with two coats of "Asphaltum" or receive equivalent coating or taping prior to placement of concrete.

c. Furnish trench duct with flat turns, riser transition fittings to wall duct or panelboard as shown, concrete tight couplings, internal barriers as required to separate services, reducers, end closers, tees and all other fittings as indicated or required.

d. Furnish coverplates of aluminum, 1/4" thickness minimum, with flush fasteners in nominal 24" lengths. Furnish grommeted openings or nipples with insulated bushings as required. Coverplates shall not deflect more than .085" with application of a 200 pound concentrated load. Any compartment over 16" in width shall have additional coverplate support, to meet the deflection criteria above.

e. Provide (as standard) an aluminum tile trim flange (verify and coordinate with floor finishes). Refer to architectural drawings, where applicable.

f. Trench duct and coverplates shall be equivalent to Square "D" Company RSV/RCP-AL series, as a standard of quality and construction.

J. CABLE TRAY OR CABLE TROUGH

(1) Cable tray shall be furnished in all-aluminum construction or galvanized steel construction, as noted and sized on the drawings.
(2) Galvanized finishes on tray shall be hot-dipped after fabrication for all trays in exterior locations. Mill finished galvanizing may be used where tray is installed indoors in dry locations.

(3) The installing contractor shall carefully follow the manufacturer's recommendations for hanger sizing and hanger support spacing. The weight per linear foot of tray, fully loaded with a 200% safety factor shall be accounted for in sizing hangers. Refer to manufacturer's instructions and/or the drawings, as applicable for hangers and supports. In no case shall supports be spaced further than 8'-0" apart.

(4) Cable tray shall be of the ladder type with rungs spaced 12" apart. Side rails shall be of I-Beam or C-Channel construction with welded rungs, depth and width as indicated on the drawings.

(5) Cable trough shall be similar to cable tray, except bottom shall be a ribbed solid piece, depth and width as indicated on the drawings.

(6) Cable tray or trough shall be provided with all required fittings for a complete installation. Fittings shall include, but not be limited to: Horizontal and vertical elbows and tees, smooth dropout fittings, end closure plates, fixed (or adjustable) splices as needed for field offsets, reducers, barriers or box connector flanges.

(7) Cable tray and trough shall be equivalent to Square "D" Company Series CLA/CLG (ladder tray) or CTA/CTG (trough) as a standard of quality and construction.

K. OPEN WIRE MESH CABLETRAY

(1) Section includes continuous, rigid, welded steel wire mesh cable management system.

(2) References
   b. ASTM A 510 - General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel.
   c. ASTM B 633 - Electrodeposited Coatings of Zinc on Iron and Steel.

(3) Design Requirements

(4) Submittals
   a. Product Data: Submit manufacturer's product data, including UL classification.
b. Shop Drawings: Submit shop drawings indicating materials, finish, dimensions, and accessories. Show layout, support, and installation details.

c. Manufacturer Qualifications: Submit manufacturer's certification indicating ISO 9002 quality certified.

(5) Delivery, Storage and Handling

a. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer and material.

b. Storage: Store materials in a dry area indoors, protected from damage, and in accordance with manufacturer's instructions.

c. Handling: Protect materials and finishes during handling and installation to prevent damage.

(6) Manufacturer

a. Cablofil, Inc., 8319 State Route 4, Mascoutah, IL, 62258. Phone (618) 566-3230. Toll Free (800) 658-4641. Fax (618) 566-3250. www.cablofil.com, or approved equivalent. Part numbers included in this section are not meant to restrict truly equivalent manufacturers.

(7) Open Wire Mesh Cabletray System

a. Description: Continuous, rigid, welded steel wire mesh cable management system.

1) Mesh System: Permitting continuous ventilation of cables and maximum dissipation of heat.

2) Safety Edge: Continuous safety edge T-welded wire lip.

3) Wire Mesh: Welded at all intersections.

b. UL Classification: Straight sections 4” x 8”, 12”, and 18 inches.

c. Material: Carbon steel wire, ASTM A 510, Grade 1008. Wire welded, bent, and surface treated after manufacture.

d. Finish for Carbon Steel Wire: Finish applied after welding and bending of mesh.

1) Hot-Dip Galvanizing: ASTM A 123. (Only in exterior, wet or corrosive locations)

2) Flat Black: Powder painted surface treatment using ASA 61 black polyester coating. (In indoor dry locations)
e. Nominal Dimensions:

1) Nominal Mesh: 2 x 4 inches.

2) Nominal Straight Section Lengths: 80 inches and 118 inches.

3) Width: [6 inches] [8 inches] [12 inches] [18 inches] [24 inches].

4) Depth: Four inches in depth for all but 6” wide, which shall be 2” depth.

5) Wire Diameter: Nominal .177 inch, minimum.

f. Fittings: Field fabricated in accordance with manufacturer's instructions from straight sections.

g. Support System: Standard.

1) Wall Installation: CS Bracket. Maximum tray width of 12 inches (300 mm).

2) Trapeze Mounting to Ceilings: CS Profile. Maximum tray width of 18 inches (450 mm).

3) Ceiling Installation: CSC Bracket. Maximum tray width of 12 inches (300 mm).

4) Fasteners: As required by tray widths. To be furnished by manufacturer.

h. Hardware: Hardware, including splice connectors, grounding fittings and support components to be furnished by the manufacturer.

i. Grounding: GTA-2-2 grounding lugs for attachment on tray of continuous ground conductor fixing system.

(8) Examination

a. Examine areas to receive cable management system. Notify the Engineer of conditions that would adversely affect the installation or subsequent utilization of the system. Do not proceed with installation until unsatisfactory conditions are corrected.

(9) Installation

a. Install open wire mesh cable tray system at locations indicated on the drawings and in accordance with manufacturer's instructions.

b. Load Span Criteria: Install open wire mesh cable tray system in accordance with span load criteria of L/240.
c. Cutting:

1) Cut wires in accordance with manufacturer's instructions.

2) Cut wires with side action bolt cutters to ensure integrity of galvanic protective layer.

3) Cut each wire with 1 clean cut to eliminate grinding or touch-up.

d. Install open wire mesh cable tray system using hardware, splice connectors, support components, and accessories furnished by manufacturer.

e. Coordinate with other trades to provide as straight and accessible runs as possible. Not all offsets are shown on drawings, but Contractor shall make accessible offsets as required around ductwork, structure, piping or other interferences as required.

L. DUCT BANKS

(1) Duct banks are defined as a raceway or raceways installed in underground locations, enclosed in a steel-reinforced concrete envelope. They shall be installed where indicated on the drawings or otherwise required.

(2) All concrete used in duct bank construction shall be 3000 PSI minimum 28 day compressive strength unless otherwise noted, in accord with latest A.C.I. standards. Testing of concrete shall be the responsibility of the Contractor, as directed by the engineer. Place concrete against undisturbed earth, or provide forming as needed.

(3) Duct bank raceways shall receive a minimum of 3" concrete cover all sides. Minimum size of any duct bank shall be 12" x 12" square, in cross section. In all cases, local and national codes shall apply to duct bank construction where they exceed the requirements of this specification.

(4) Each corner of duct bank shall receive a minimum No. 4 steel reinforcing bar with 2" minimum concrete cover on all sides. Lap bars fifteen diameters at all splices. Provide stirrup bars bury 60" on center to tie bars together. Stirrups may be #3 bar. Reinforcing steel shall be rigidly supported during pour and vibration, and shall be constructed to ASTM standards.

(5) Support for encased raceways shall be as recommended by raceway manufacturer, spaced 8'-0" maximum on centers, rigidly fastened to prevent floating of ducts during concrete pours. Supports shall be of a material compatible with the raceway, and shall be of the interlocking type, forming a rigidly braced installation. Provide base type and intermediate type spacers to suit conduit configurations and sizes.

(6) Where rigid nonmetallic raceways leave concrete duct banks, a transition to rigid steel conduit shall be made 18" inside the concrete envelope. Under no circumstances shall PVC,
EB or similar ducts exit concrete envelope, except where duct bank ties into a manhole wall. Provide bell ends at such terminations and dowel duct bank rebars 4" into manhole wall with non-shrink grout. Refer to details on drawings, as applicable. Slope all raceways within duct bank systems such that they shall drain into manholes or pull boxes. Provide proper drainage at manholes or pull boxes to prevent water accumulation.

(7) Where ducts transition thru manholes, pull boxes or at terminating end, each duct shall be specifically identified. A nomenclature as shown on the drawings or as agreed upon by the installer and engineer shall be utilized to identify each individual duct. A permanent means of identifying each duct, such as engraved laminoid plates or stamped metal tags shall be used.

M. RACEWAY FITTINGS

(1) Raceway fittings (or condulets) shall be of gray iron, malleable iron or heavy copper-free cast aluminum. They shall be furnished in proper configurations, avoiding excessive plugged openings. Any openings that are left shall be properly plugged. All coverplates shall be gasketed with neoprene or similar approved materials, rated for the environment.

(2) Where required, raceway fittings shall be provided in explosion-proof configurations rated for the atmosphere. Place conduit seal off fittings at each device in accord with applicable codes. Seal off fittings shall be packed with wadding, and poured with an approved non-shrink sealing compound.

(3) Where conduit transitions in a run from a cold to a warm environment, (such as at a freezer, refrigerator or exterior wall) sealoff fittings shall be placed on the warm side immediately at the boundary to prevent migration of condensation within raceway systems.

(4) Expansion fittings shall be provided at all locations where conduits or other raceways cross over expansion joints. Provide copper ground bonding jumpers across expansion fittings.

(5) Conduit bodies, junction boxes and fittings shall be dust tight and threaded for dusty areas, weatherproof for exterior locations and vapor tight for damp areas. Conduit fittings shall be as manufactured by Crouse Hinds, Appleton, Killark or approved equivalent. All surface mounted conduit fittings as with "FS", "FD", "GUB" Types etc., shall be provided with mounting hubs.

(6) Where lighting fixtures, appliances or wiring devices are to be suspended from ceiling outlet boxes, they shall be provided with 3/4" rigid conduit pendants. Outlet boxes shall be malleable iron, provided with self-aligning covers with swivel ball joint and No. 14 gauge steel locking ring. Provide safety chain between building structure and ballast housing of light fixtures for all fixtures, appliances or devices greater than 10 lbs weight. Fixtures shall be installed plumb and level.

(7) Fittings for threaded raceways shall be tapered thread with all burrs removed, reamed ends and cutting oil wiped clean.
(8) Fittings for E.M.T. conduit shall be of the compression type. Conduit stops shall be formed in center of couplings. All EMT connectors and couplings shall be of formed steel construction.

(9) Indentation or die-cast fittings shall not be permitted in any raceway system.

(10) All conduit fittings shall be securely tightened. All threaded fittings shall be engaged seven full threads. Fasteners shall be properly torqued to manufacturer's recommendations.

N. SUPPORTS AND HANGERS

(1) Supports and hangers shall be installed in accord with all applicable codes and standards. They shall be corrosion-resistant, galvanized or furnished with an equivalent protective coating. All electrical raceways shall be hung independently from the building structure with U.L. listed and approved materials. Hangers and supports depending on the support systems of other trades’ work shall not be permitted, except with specific approval in writing from the Engineer. The use of tie wire for support or fastening of any raceway system is prohibited. Perforated metal tape shall not be used for raceway support.

(2) No raceway shall be installed on acoustic tile ceiling tees, or in any location that will impair the functioning, access or code-required clearances for any equipment or system.

(3) Supports for raceways shall be of materials compatible with the raceway, of malleable iron, spring steel, stamped steel or other approved material. Die-cast fittings are not permitted for supports.

(4) The installing contractor shall provide all necessary supports and braces for raceways, in a rigid and safe installation, complying with all applicable codes.

(5) Individual conduits run on building walls or equipment shall be secured by one hole galvanized malleable iron or stamped steel pipe strap or "minerallac" 2-piece straps. The straps are to be anchored by an approved means such as expansion anchors, toggle bolts, through bolts, etc. Where required by codes or other standards, provide spacers behind mounting clamps to space conduits off walls.

(6) Individual conduits run on building steel shall be secured by means of clamp supports similar and equal to those manufactured by the C.C. Korn Company, Elcen Co., B-Line or approved equivalent. Provide korn clamps, bulb tee clamps, flange clamps, beam clamps, "minerallacs", etc.

(7) Where feasible, vertical and/or horizontal runs of conduit shall be grouped in common hangers on "trapezes" of channel stock as manufactured by "Unistrut" or equivalent, 1-5/8" minimum depth, 12 gauge. Utilize conduit clamps appropriate to the channel.
(8) Channel strut systems for supporting electrical equipment or raceways in outdoor wet or corrosive locations shall be constructed of 12 gauge minimum hot dip galvanized steel with 9/16" diameter holes on 8" centers, with finish coat of paint as manufactured by Unistrut, B-Line, Kindorf, or approved equivalent. In indoor dry locations, factory finish paint will be acceptable.

(9) The minimum diameter of round all-thread steel rods used for hangers and supports shall be 1/4", 20 threads per inch. All-thread rod shall be furnished with a corrosion-resistant finish.

(10) Welding directly on conduit or fittings is not permitted.

(11) Provide riser support clamps for vertical conduit runs. Riser support clamps shall be of heavy gauge steel construction. Install riser support clamps at each floor level penetration, or as otherwise required.

(12) Provide conduit cable support clamps for vertical conductor runs as required or indicated on plans. Clamps to be insulating wedging plug, with malleable iron support ring. Install within properly sized and anchored junction box.

(13) Spring steel clips and fittings such as those manufactured by HITT-Thomas, Caddy-Erico, or approved equivalent, with black oxide finish are permitted in any indoor dry location for concealed work, where acceptable to the local authority having jurisdiction.

3. INSTALLATION

A. This Contractor shall lay out and install all conduit systems so as to avoid any other service or systems, the proximity of which may prove injurious to the conduit, or conductors which it confines. All conduit systems, except those otherwise specifically shown to the contrary, shall be concealed in the building construction or run above ceilings. Size of all conduit shall as a minimum conform to the National Electrical Code, unless larger size is indicated on the Contract Drawings.

B. No conduit larger shall be installed in poured concrete slabs except with permission of the structural engineer. All other shall be held below slab. Conduit shall be held at least 6" from flues or hot water pipes.

C. All exposed conduit shall be installed with runs parallel or perpendicular to walls, structural members or intersections of vertical planes and ceilings, with right angle turns consisting of cast metal fittings or symmetrical bends unless otherwise shown. All conduit shall have supports spaced not more than eight feet apart.

D. All conduits within Gymnasium’s shall be concealed within walls. Where conduits are exposed for final connections to pendant mounted light fixtures, motorized basketball goals, or other exposed equipment/devices, the conduits shall be routed tight and parallel or perpendicular to structural members and shall remain concealed up to the ceiling structure elevation.
E. Conduit shall be installed in such a manner so as to insure against collection of trapped condensation. All runs of conduit shall be arranged so as to be devoid of traps. Trapped conduit runs shall be provided with explosion proof drains at low points. Runs of conduit between junctions shall not have more than the equivalent of three 90º bends.

F. Junction boxes shall be installed so that conduit runs will not exceed 85', as shown on the Contract Drawings.

G. Underground electric, cable TV, telephone service or other rigid steel conduit and underfloor rigid steel conduit below the concrete floor slab shall be painted with two coats of bitumastic paint, such as "Asphaltum".

H. All underground or underfloor conduits shall be swabbed free of all moisture and debris before conductors are pulled.

I. At least two 1 inch and four 3/4 inch conduits shall be stubbed from flush-mounted panelboards into the nearest accessible area for future use. Provide suitable closures for these stubs. Identify each stub with a suitable hang tag.

J. Install electrical raceways in accordance with manufacturer's written instructions, applicable requirements of latest edition of the N.E.C., and NECA "Standard of Installation", complying with recognized industry practices.

K. Coordinate with other trades, including metal and concrete deck trades, as necessary to interface installation of electrical raceways and components.

L. Level and square raceway runs, and install at proper elevations and required heights. Hold tight to structure or route through joists webbing wherever possible, to maximize available space and not restrict other trades.

M. Complete installation of electrical raceways before starting installation of cables or wires within raceways.

N. All underground conduits shall be buried to minimum depth of 24" from the top of the concrete encasement or raceway to finished grade, unless otherwise noted on plans. Observe minimum burial requirements of local utility company where their standards or regulations apply. Conduits containing primary power conductors, (higher than 600 volts to ground) shall be 42" to top below finished grade, unless otherwise noted on plans.

O. All raceways shall be installed to maintain a minimum of 4" clearance below roof decking.

4. SPECIALTIES

A. All EMT terminations at junction boxes, panels, etc. shall be made with case hardened locknuts and appropriate fittings, with insulated throat liners. Insulating terminations shall be manufactured as a single unit. The use of split sleeve insulators is not permitted.
B. All rigid conduit, except main and branch feeders, shall have heavy fiber insulating bushings reinforced with double locknuts. All branch and main feeders shall have insulated bushings with grounding lugs and shall be bonded to enclosures with appropriately sized copper jumpers, except at pad mounted transformers. Bonding jumpers shall be installed as required by the N.E.C. and other applicable codes.

C. All conduit stubbed through floor during construction shall have openings protected with plastic caps approved for this purpose. Connections on both ends of all flexible conduit shall be equivalent to Thomas and Betts, Ideal, Appleton, Efcor, or approved equivalent, rated for the environment.

D. All pulling lines left in open conduit systems shall be non-metallic, left securely tied off at each end.

E. Where spare raceways terminate in switchboards or motor control centers a fishtape barrier shall be provided.

END OF SECTION.
SECTION 16135 - CABINETS, OUTLET BOXES AND PULL BOXES

1. GENERAL

A. This section of the specifications covers all electrical cabinets, outlet boxes and pull boxes.

B. Continuous runs of conduit shall have properly sized pull boxes at least each eighty-five feet of run, or as near as possible to that limit.

2. MATERIALS AND INSTALLATION

A. Cabinets, Outlet And Pull Boxes:

(1) Cabinets for lighting and power, telephone, pull boxes, outlet boxes, or any other purposes specified or shown on the Contract Drawings, shall be constructed of code gauge, galvanized steel with sides formed and corner seams riveted or welded before galvanizing. Boxes assembled with sheet metal screws will not be accepted. Pull boxes shall include all boxes used to reduce the run of conduit to the required number of feet or bends, supports, taps, troughs, and similar applications and shall also be constructed as specified above.

(2) All cabinets and boxes for NEMA 1 and 1A application shall be provided with knockouts, as necessary, or shall be cut in the field by approved cutting tools which will provide a clean, symmetrically cut opening. All boxes, except panelboards, shall be provided with code gauge fronts with hex head or pan head screw fasteners. Outdoor cabinets shall be hinged cover with pad locking provisions. Fronts for panelboards shall be as specified for panelboards.

(3) Ceiling outlet boxes shall be galvanized steel, 4" octagonal, not less than 2 1/8" deep, with lugs or ears to secure covers. Those for use with ceiling lighting fixtures shall be fitted with 3/8" fixture studs fastened to the back of the boxes, where applicable. Provide adequate support with at least a 2 x safety factor for the anticipated fixture weight.

(4) Special size concealed outlet boxes for clocks, speakers, alarms, panels, etc., shall be provided by the manufacturer of the equipment.

(5) Floor outlet boxes shall be as specified in Section 16140, fully adjustable unless noted or specified otherwise.

(6) Unless otherwise noted on the drawings or in the specifications, outlet boxes shall be installed at the following heights to centerline of box:

- Wall Switches, Control Stations ................................................................. 3'-10"
- Convenience Outlets .................................................................................. 1'-6"
- Convenience Outlets - Above Counters......................Bottom at 2" above top of backsplash
- T.V. Outlets ................................................................................................. 1'-6"
(7) The location of outlets, as shown on the drawings, shall be considered as approximate only. It shall be incumbent upon this Contractor to study the general building drawings, with relation to spaces surrounding each outlet, in order to make his work fit the work of others and in order that when the devices or fixtures are installed, they will be symmetrically located and will not interfere with any other work or equipment. Any change in fixture or layout shall be coordinated with and approved by the Engineer before this change is made. Regardless of the orientation shown on the drawings, all devices shall be easily accessible when installed.

(8) Boxes installed in fire rated assemblies shall not compromise the rating of the assembly. The Contractor is responsible for identifying assembly ratings and construction requirements prior to rough-in.

   a. Listed single and double gang metallic outlet and switch boxes with metallic or nonmetallic cover plates may be used in bearing and nonbearing wood stud and steel stud walls with rating not exceeding 2 h. The boxes shall be fastened to the studs with the openings in the wallboard facing cut so that the clearance between the boxes and the wallboard do not exceed 1/8 in. The boxes shall be installed so that the surface area of individual boxes do not exceed 16 sq in, and the aggregate surface area of the boxes do not exceed 100 sq in per 100 sq ft of wall surface unless approved alternate protection materials are used.

   b. Boxes located on opposite sides of walls or partitions shall be separated by a minimum horizontal distance of 24 in. This minimum separation distance between the boxes may be reduced when listed Wall Opening Protective Materials are installed according to the requirements of their Classification.

   c. Boxes installed on opposite sides of walls or partitions of staggered stud construction shall have listed Wall Opening Protective Materials installed with the boxes in accordance with Classification requirements for the protective materials.

   d. All installation shall be done in accordance with AHJ requirements.

(9) All outlets, pull boxes, junction boxes, cabinets, etc., shall be sized per the current edition of the National Electrical Code.

B. Cabinets, outlet boxes and junction or pull boxes shall be threaded for rigid-threaded conduit, dust-tight, vapor-tight or weatherproof as required for areas other than for NEMA 1 or 1A
application. These shall be as manufactured by Crouse-Hinds, Appleton, Killark, or approved equivalent.

(1) NEMA 1 or 1A cabinets, outlet boxes or pull or junction boxes shall be as manufactured by Appleton, Steel City, T & B, or approved equivalent.

(2) Outlet boxes for switches, receptacles, telephone, etc., concealed in walls shall be galvanized steel, 2" X 4" X 2" with plaster cover for the number of devices as required. Where outlet boxes are installed in walls of glazed tile, brick, concrete block, or other masonry which will not be covered with plaster or in walls covered by wood wainscot or paneling, deep sectional masonry boxes shall be used and they shall be completely covered with the plates or lighting fixtures. This Contractor shall cooperate with the brick layers, block layers and carpenters to insure that the outlet boxes are installed straight and snugly in the walls. Receptacles shall be set vertically in walls, unless noted otherwise.

(3) Outlet boxes mounted in glazed tile, brick, concrete block or other types of masonry walls shall be mounted above or below the mortar joint. Do Not Split The Mortar Joint.

(4) Boxes for more than two devices shall be for the number of devices required and shall be one piece. No ganging of single switch boxes will be allowed.

(5) Outlets provided shall have only the holes necessary to accommodate the conduit at the point of installation and shall be rigidly secure in position. Boxes with knockouts removed and openings not used shall be replaced or be provided with a listed knockout closure.

(6) Openings for conduit entrance in cabinets and boxes shall be prefabricated, punched, drilled and/or reamed. The use of a cutting torch for this purpose is prohibited.

END OF SECTION.
SECTION 16140 - WIRING DEVICES AND PLATES

1. GENERAL

   A. This section of the specifications includes wiring devices, cover plates, weatherproof and dust-tight closures, communications devices and floor outlets.

   B. Wiring devices are listed by manufacturer and catalog numbers to establish the quality and type required. Equivalent devices of other manufacturers will be acceptable with prior approval of the Engineer. Submit cutsheets and/or samples of each type ten days prior to bid date for review and written approval to bid. Insofar as possible, standard application or special application devices shall be by one manufacturer.

2. MATERIALS

<table>
<thead>
<tr>
<th>TYPE</th>
<th>RATING</th>
<th>CONFIGURATION</th>
<th>COLOR</th>
<th>VENDOR - CAT. #</th>
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* USE WHEN ON DEDICATED 20A CKT., OR CALLED OUT
** USE WHEN ON DEDICATED 15A CKT., OR WHERE MORE THAN ONE RECEPTACLE ON A CIRCUIT

WIRING DEVICES
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<tr>
<th><strong>RECEPTACLE</strong></th>
<th><strong>VOLTAGE</strong></th>
<th><strong>AMP</strong></th>
<th><strong>RECEPTACLE</strong></th>
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**Note:**

Switch, keyed to each be furnished with one Hubbell #1209 key. Turn over to owner at close of project and obtain receipt for verification that keys have been delivered.

| Switch, Momentary, 3-Position, Center Off Switch, Pilot (Toggle Lit in Off Position) | 120/277V, 20A (Verify Voltage Used) | SPDT | ! | Hubbell HBL Series GE Equivalent Leviton Equivalent |
| Switch, Pilot (Toggle Lit in Off Position) | 120/277V, 20A (Verify Voltage Used) | SPDT Or As Noted | CLEAR "LEXAN" | Hubbell HBL Series GE Equivalent Leviton Equivalent |
| Switch, Pilot (Toggle Lit in On Position) | 120/277V, 20A (Verify Voltage Used) | SPST Or As Noted | CLEAR "LEXAN" | Hubbell HBL-PL7 Series GE Equivalent Leviton Equivalent |
| Timer Switch | 120V | SPST, 15 Minute | ! | Nutone VS63 GE Equivalent Leviton Equivalent |

**Notes:**

1. Provide matching cap (plug) for all receptacles 30 amp rated and above as required for equipment.

2. All receptacles shall be back or side-wired, clamping type.

3. For dryers and ranges, provide 3-pole grounding type as required by device. Locate device so that dryer or range can be pushed tightly against wall.
4. RECEPTACLES SHALL BE TAMPER RESISTANT AND WEATHER RESISTANT AND MARKED ACCORDINGLY AS REQUIRED BY N.E.C.

5. ALL RECEPTACLES INSTALLED IN DUMP OR WET LOCATIONS SHALL BE UL LISTED WEATHER RESISTANT TYPE.

! SEE ARTICLE 3, COLOR.

A. Small Motor Control Switches:

   (1) For small line-to-neutral motor loads of 3/4 HP or less, single phase, rated at 120 or 277 volts, provide snap-type, H.P. rated motor starter switch with thermal overloads. Overload heaters sized to match the motor nameplate amperes and the ambient temperature shall be provided. Provide with NEMA 1, NEMA 3R or other enclosure suitable for the location and atmosphere. All manual starters in finished areas shall be in flush-mounted enclosures.

3. COLOR

A. Color of devices shall be as selected by the architect. Samples (devices, plates or both) may be required to be submitted with other architectural color items by the Contractor. The Contractor shall coordinate any such submission required with other trades, the Prime Contractor or as needed.

B. Where devices are controlling or supplying emergency power from a standby source, the device color shall be red, as with switch toggles or receptacle fronts. Plate color shall match others on normal power in the building unless otherwise noted.

C. Where surface finishes next to the devices vary in color or shade throughout the project, the Contractor may be required to provide lighter or darker plates and devices to more closely match wall finishes. These variations are considered to be included in the original contract for construction.

4. MANUAL DIMMERS

A. Manual dimmers for incandescent, MR-lamp incandescent or fluorescent loads shall be matched to the type load intended to be controlled.

B. Power rating shall be verified by examining the plans and suitable for the load, but in no case less than circuit load. Furnish dimmers in nominal power ranges of 600W, 1000W, 1500 watts, etc.

C. Manual dimmers shall be provided with all solid state components, complete with choke coil and/or other R.F.I. suppression devices.
D. Manual dimmers shall be suitable for mounting in single gang outlet box, ganging together in multi-section boxes where indicated, without derating being necessary.

E. Manual dimmers shall be of the sliding-type, with detent stop at off position, full range control 0-100%. Lutron Company "Nova" Series or equivalent Lithonia, Lightolier.

F. Manual dimmers for fluorescent lighting or low voltage transformer-fed incandescent fixtures shall be matched to suit the characteristics of the particular manufacturer's electronic ballast or transformer used in the dimming-type fixture. Submit shop drawings of dimmer in the same submittal as the lighting fixtures.

5. PLATES AND COVERS

A. Unless otherwise specified or noted, all wiring device plates and covers shall be smooth thermoplastic, Hubbell "P" Series or equivalent G.E. or Leviton. Color shall match device unless otherwise indicated.

B. All kitchen, gymnasium or food service area plates shall be bright finish 302 stainless steel.

C. Cover plates shall be of one manufacturer insofar as possible.

D. Weatherproof plates for G.F.C.I. receptacles shall be cast aluminum, self-closing, gasketed, suitable for standard box mounting, U.L. listed for wet location use, cover closed. Vertical mounting - Hubbell WP26M, horizontal mounting - Hubbell WP26MH (die-cast zinc) or equivalent Leviton or G.E.

E. Weatherproof switch plates for toggle-handle switches shall be clear silicone rubber, for standard outlet boxes. Hubbell 1795 or equivalent G.E. or Leviton.

F. Cover plates for computer, telephone or other system outlets shall be as required to meet supplier or the owner's requirements, as applicable. Color to match other plates on project. Furnish telephone plates with wall-mounting studs if mounted at 48" or higher. See devices schedule below.

6. INSTALLATION

A. All wiring devices in dusty areas, exposed to weather and moisture shall be installed in Type "FS" or similar conduit fittings having mounting hubs, with appropriate cover plates.

B. Devices that have been installed before painting shall be masked. No plates or covers shall be installed until all finishing and cleaning has been completed.

C. Provide G.F.C.I. duplex feed-thru style receptacles in accordance with new U.L. Standard 943 where indicated or required by the National Electrical Code, whether specifically called out or not. When a G.F.C.I. receptacle is on a circuit with other non-G.F.C.I. receptacles, it shall always be placed at the homerun point of the circuit and shall be wired to ground-fault interrupt
protect the downstream outlets on that circuit unless specifically indicated to the contrary. Provide a "G.F.C.I. protected" label on each downstream outlet.

D. GFCI devices shall be installed in a “readily accessible” location per NEC requirements. GFCI protected outlets required by plans or code shall be fed by a GFCI breaker or upstream GFCI device if they are not readily accessible.

E. Where surge suppression outlets are provided, they shall be ANSI Category "A" style. They shall be installed as dedicated-circuit outlets or where indicated with multiple outlets on a circuit, they shall be placed at the homerun point of that circuit and feed-thru wired to protect the downstream outlets on that circuit.

F. All receptacles shall be installed with ground prong at top position.

G. All outlets not provided with wiring devices shall be closed with a blank plate matching other plates in the area.

END OF SECTION.
SECTION 16230 - EMERGENCY GENERATOR

1. GENERAL

A. RELATED DOCUMENTS:

   (1) Drawings and general provisions of Contract, including General and Supplementary
       Conditions and Division 1 Specification sections apply to work of this section.

   (2) Division 26 Basic Materials and Methods sections apply to work specified in this section.

2. DESCRIPTION OF WORK:

A. Extent of standby generator system work is indicated by drawings and schedules.

B. Types of standby generator system equipment required for project include the following:

   (1) Natural gas engine driven generator.

   (2) Automatic Transfer Switches, Batteries and Chargers.

3. QUALITY ASSURANCE:

A. General Requirements: It is the intent of this specification to secure an emergency generator
   system that has been prototype tested, factory built, production tested, site tested, of the latest
   commercial design, together with all accessories necessary for a complete installation as
   shown on the plans and drawings, and specifications herein. The equipment supplied and
   installed shall meet the requirements of the National Electrical Code, along with all applicable
   local codes and regulations. All equipment shall be new, of current productions of a national
   firm. The standby generator set(s) including generator, controls, and transfer switch(es), shall
   be assembled as a matched unit so that there is a one-source responsibility for warranty, parts,
   and service without a local representative with factory-trained servicemen.

B. Manufacturers: Firms regularly engaged in manufacture of engine driven standby generator
   systems, of types, ratings and characteristics required, whose products have been in
   satisfactory use in similar service for not less than 5 years.

C. Installer: Qualified with at least 5 years of successful installation experience on projects with
   engine generator system installation work similar to that required for project.

D. NEC Compliance: Comply with applicable standby generator requirements of NEC including,
   but not limited to emergency and standby power generating systems, and Articles 230, 517,
   700, 701, and 702.

E. NFPA Requirements: Comply with applicable requirements of NFPA No. 37, 101, 110
   pertaining to stationary combustion engines, institutional facilities and life safety code.
F. UL Compliance: Comply with applicable requirements of UL 1008, "Automatic Transfer Switches". Provide standby generator system components, including automatic transfer switches, which are UL listed and labeled with a circuit breaker mounted on the set.


4. SUBMITTALS:

A. Submittal shall include prototype test certification and specification sheets showing all standard and optional accessories to be supplied, schematic wiring diagrams, dimension drawings, and interconnection diagrams identifying by terminal number, each required interconnection between the generator set, the transfer switch, and the remote annunciator panel if it is included elsewhere in these specifications. Include manufacturer's standard product warranty (for not less than five years) for replacement of materials and equipment used in standby engine-driven generator system. Warranty shall start at Final Project Completion.

B. Maintenance Data: Submit maintenance instructions, including lubrication procedures, motor and drive replacement, and spare parts lists. Include this data in maintenance manuals.

5. PRODUCTS

A. ACCEPTABLE MANUFACTURERS:

(1) Manufacturer: Subject to compliance with requirements, provide standby generator systems of one of the following (for each type of electric generator unit): Generac, Cummins, Kohler Co., or Caterpillar

B. EQUIPMENT:

(1) The natural gas driven generator set shall be rated continuous standby (defined as continuous for the duration of any power outage) 120/208 Volts, 3 phase, 4 wire, .8PF, 200 KW/250 KVA, at 1950 feet altitude, 104 degrees F.

(2) The generator set shall be capable of starting motor loads of 497 KVA inrush, at 90% sustained voltage.

(3) Provide generator mounted load center for miscellaneous generator loads.

C. ENGINE:
(1) The engine shall deliver a governed speed of 1800 RPM. The engine shall be equipped with the following:

(2) Isochronous governor capable of +/- 0.25% steady-state frequency regulation.

(3) Volt positive engagement solenoid shift-starting motor.

(4) Ampere minimum automatic battery charging alternator with solid-state voltage regulation.

(5) Positive displacement, full pressure lubrication oil pump, cartridge oil filters, dipstick, and oil drain.

(6) Dry-type replaceable air cleaner elements for (normal/heavy) duty application.

(7) Engines requiring glow plugs will not be acceptable.

(8) Provide battery charger with time delay relay connected to emergency power service to prevent nuisance alarm during testing.

D. GENERATORS:

(1) The alternator shall be salient-pole, brushless, 12-lead reconnectable, 2/3 pitch, self-ventilated of drip-proof construction with amortisseur rotor windings and skewed stator for smooth voltage waveform. The insulation shall meet the NEMA Standard (MG1-22.40 and 1 6.40) for Class H and be insulated with epoxy varnish to be fungus resistant per MIL 1-24092. Temperature rise of the rotor and stator shall be limited to 105°F.

(2) The excitation system shall be of brushless construction controlled by a solid-state voltage regulator capable of maintaining voltage within +/- 2% at any constant load form 0% to 100% of rating. The regulator must be isolated to prevent tracking when connected to SCR loads, and provide individual adjustments for voltage range, stability and volts-per-hertz operation; and be protected from the environment by conformal coating.

(3) Upon one-step application of any load up to 100% of the rated load at 0.8 power factor, the voltage dip shall not exceed 20% and shall recover to +/- 2% of rated voltage within one second.

(4) The generator shall be capable of sustaining at least 300% of rated current for at least 10 seconds under a three-phase symmetrical short by inherent design.

(5) A resettable line current sensing circuit breaker with inverse time versus current response shall be furnished which protects the generator from damage due to its own high current capability. This breaker shall not trip within the 10 seconds specified above to allow selective tripping of down-stream fuses or circuit breakers under a fault condition. This
breaker shall not automatically reset preventing restoration of voltage if maintenance is being performed. Field current-sensing breaker will not be acceptable.

(6) The generator, having a single maintenance-free bearing, shall be directly connected to the flywheel housing with a semi-flexible coupling between the rotor and the flywheel.

(7) The engine generator unit shall be mounted on a structural steel sub-base and shall be provided with suitable vibration isolators between generator set frame and the base mounting rails. The generator set shall be installed on a minimum 4” high concrete pad that is crowned in the center to permit full drainage from beneath the unit. It shall be securely fastened to the pad in a manner as approved by the generator set manufacturer. The concrete pad shall extend at least six inches beyond the generator outline or housing in all directions. For outdoor installations, the concrete pad shall extend 24” beyond the housing at access panels opening to control panels or equipment points requiring service. Housing shall be NEMA 3r rated weather-protected enclosure.

(8) Safety Devices – Safety shutoffs for high coolant temperature, low coolant levels, low oil pressure, overspeed, and engine overcrank shall be provided.

E. CONTROLLER:

(1) The NEMA 1 enclosed control panel shall be mounted on the generator set with vibration isolators. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered. The generator set mounted control shall include the following features and functions:

a. Three position control switch labeled RUN/OFF/AUTO. In the RUN position the generator set shall automatically start, and accelerate to rated speed and voltage. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.

b. RESET switch: The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.

c. PANEL LAMP switch: Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power.

d. Generator set AC output metering: The generator set shall be provided with a metering set with the following features and function:

   1) Analog AC Voltmeter, dual range 90 degree scale, 2% accuracy; Analog AC Ammeter, dual range, 90 degree scale, 2% accuracy; Analog Frequency/RPM meter, 45-65 Hz, 1350-1950 RPM, 90 degree scale, +/- 0.6 Hz accuracy.

   2) Seven position phase selector switch with OFF position to allow meter display of current and voltage in each generator phase. When supplied with
reconnectable generators, the meter panel shall be reconnectable for the voltage specified.

3) Generator Set Alarm and Status Display: The generator set shall be provided with alarm and status indicating lamps to indicate non-automatic generator status, and existing alarm and shutdown conditions. The lamp condition shall be clearly apparent under bright room lighting conditions. The generator set control shall indicate the existence of the following alarm and shutdown conditions on the display panel:

- Common fault (alarm)
- Battery charger failure (alarm)
- High/Low batter voltage (alarm)
- Master switch not in auto (alarm)
- Low fuel (alarm)
- Switch off (flashing)
- Low oil pressure (alarm)
- Low oil pressure (shutdown)
- Low coolant temperature (alarm)
- High coolant temperature (alarm)
- High coolant temperature (shutdown)
- Low coolant level (shutdown)
- Overcrank (shutdown)
- Overspeed (shutdown)
- Ground fault (alarm) (optional-when required by code or specified)
- Emergency stop (alarm)

(2) In addition, provisions shall be made for indication of two customer-specified alarm or shutdown conditions. The non-automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.

(3) Engine Status Monitoring: The following devices shall be provided on the generator set control:

- Engine oil pressure gauge
- Engine coolant temperature gauge
- Engine operation hour gauge
- Battery voltage (DC volts)

(4) Control Functions: The control system provided shall include a cycle cranking system, which shall be for 3 cranking periods of 15 seconds each, with 15 second rest period between cranking periods. Fail to start shall be indicated by operation of the overcrank alarm indication lamp.

(5) Alternator Control Functions: The generator set shall include an automatic voltage regulation system which is matched and prototype tested with the governing system
provided. It shall be immune from misoperation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below a threshold of 58-59 Hz for 60 Hz machines, and 48-49 Hz for 50 Hz machines.

(6) Voltage adjusting rheostat, locking screwdriver type, to adjust voltage +/- 5% from rated value.

6. AUTOMATIC STARTING SYSTEM

   A. A 12 or 24-volt DC electric starting system with positive engagement drive shall be furnished.

   B. Fully automatic generator set start/stop controls in the generator control panel shall be provided. Controls shall provide shut down for low oil pressure, high coolant temperature, low coolant level, overspeed, overcrank with one auxiliary convertible contact for activating accessory items. Controls shall include a thirty-second single cranking cycle limit with lockout. Provide interconnecting wiring in conduit to remote annunciator (if specified) as required.

   C. A 12 or 24-volt lead acid storage battery set of the heavy-duty starting type shall be provided. The battery set shall be of sufficient capacity to provide for 12 minutes total cranking time without recharging, with sufficient amp hour rating to suit the engine selection. A corrosion-resistant battery rack, necessary cables, and clamps shall be provided. Provide connection using THWN wiring in conduit to battery charger, as required.

   D. For outdoor installations, provide battery warming pads rated at 120 volts input, in accord with the battery manufacturer’s recommendations. Provide normal power 120 volt circuit as required.

   E. A current limiting automatic two-rate battery charger shall be furnished to automatically recharge batteries. Charger shall float at 2.17 volts per cell and equalize at 2.33 volts per cell. It shall include overload protection, silicone diode full wave rectifiers, voltage surge suppressors, DC ammeter, and fused AC input. AC input voltage shall be 120 volts. Provide emergency generator powered circuit as required. Amperage output shall be no less than ten amperes.

   F. A unit mounted thermal circulation type water heater(s) controlled by a thermostatic switch shall be furnished to maintain engine jacket water to 120°F in an ambient temperature of 0°F. Provide for 120 or 208 volt, single phase operation, per manufacturer’s recommendation. Provide normal utility source power circuit as required.

7. FACTORY INSTALLED ACCESSORIES: Provide the following factory installed accessories:

   A. Block heater, dual 1500-Watt 208 volt AC. Thermostatically controlled and sized to maintain engine coolant at proper temperature to meet the requirements of NFPA-110 Regulation.
B. Overvoltage protections will shutdown the unit after one second of 15% or more overvoltage. Note: Sensitive equipment may suffer damage in less than one second of an overvoltage condition. On-line equipment requiring faster shutdown should have its own overvoltage protection.

C. A battery box heater shall be included.

D. Two main line circuit breakers 3-pole, solid state electronic trip with 100% rating shall be provided for the generator. Refer to drawings for sizing.

8. ACCESSORIES: Provide the following accessories:

A. Battery rack, battery cables, 12-Volt lead - antimony battery(ies) capable of delivering the manufacturer's recommended minimum cold-ranking Amps required at 0 Degrees F. per SAE Standard 7-537, shall be supplied. Steel insulated rack for batteries.

B. Battery charger shall be located within the automatic transfer switch.

C. 12v/15 Ampered automatic float and equalize battery charger with +/- 1% constant voltage regulation from no load to full load over +/- 10% AC input line variation, current limited during engine cranking and short circuit conditions, temperature compensated for ambient from -40 degrees C. to + 60 degrees C., 5% accurate voltmeter and ammeter, fused, reverse polarity and transient protected. Alarm circuit shall be included to meet the requirements of NFPA 110 for low battery voltage and alarm board per NFPA, high battery voltage, and battery charger malfunction, DC voltmeter, DC ohmmeter, high float switch. Charger should connect to emergency AC circuit and be equipped with controls to delay alarm for malfunction to allow transfer time in normal conditions. Provide in Nema 1 enclosure.

D. Gas-proof, seamless, stainless steel, flexible exhaust bellows with threaded NPT connections. The engine exhaust silencer shall be coated to be temperature and rust resistance with integral condensate drain, rated for critical application. Exhaust noise shall be limited to 85 dBA as measured at 10 feet in a free-field environment.

E. One (1) remote annunciator shall monitor all controller functions plus line power and generator power monitoring. An integral lamp test and horn silencer switch shall be included, as required to meet NFPA 110. Provide complete installation as required. Refer to drawings for locations. Provide emergency generator kill switch at annunciator location.

F. Anchor Bolts: Galvanized steel, of types and sizes indicated.

G. Furnish anchor bolts to concrete formwork Installer with installation drawings and instructions.

H. All sheet metal shall be primed for corrosion protection and finish painted with the manufacturer’s standard color using a two step electrocoating paint process, or equal meeting the performance requirements specified below. All surfaces of all metal parts shall be primed and painted. The painting process shall result in a coating that meets the following requirements:
• Primer thickness, 0.5-2.0 mils. Top coat thickness, 0.8-1.2 mils.

• Gloss, per ASTM D523-89, 80% plus or minus 5%. Gloss retention after one year shall exceed 50%.

• Crosshatch adhesion, per ASTM D3359-93, 4B-5B.

• Impact resistance, per ASTM D2794-93, 120-160 inch-pounds.

• Salt Spray, per ASTM B117-90, 1000+ hours.

• Humidity, per ASTM D2247-92, 1000+ hours.

• Water Soak, per ASTM D2247-92, 1000+ hours.

I. Painting of hoses, clamps, wiring harnesses, and other non-metallic service parts shall not be acceptable. Fasteners used shall be corrosion resistant, and designed to minimize marring of the painted surface when removed for normal installation or service work.

J. A factory-critical type exhaust silencer with bird screen shall be provided for generator.

K. Flexible fuel line

L. Pre-alarm senders

9. AUTOMATIC TRANSFER SWITCHES:

A. It is the intent of this specification to secure an automatic transfer switch that has been prototype tested, factory built, productions tested, site tested, together with all accessories necessary or a complete installation as shown on the plans and drawing and specified herein. All equipment shall be new, of current production by a national firm. The automatic transfer switch shall conform to the requirements of NEMA Standards ICS 2-447 and Underwriter's Laboratories UL-1008 and shall be UL listed as follows:

(1) For use in emergency systems in accordance with Articles 517 and 700 of the National Electric Code.

(2) Rated in Ampered for total system transfer including control of motors, electric-discharge lamps, electric-heating and tungsten-filament lamp load. Switches rated above 600 Amperes shall be suitable for 30% or 600 Amperes tungsten-filament lamp load, whichever is higher.

B. The automatic transfer switch shall consist of a power transfer module and a control module, interconnected to provide complete automatic operation. The automatic transfer switch shall be mechanically held and electrically operated by a single-solenoid mechanism energized from the source to which the load is to be transferred. The switch shall be rated for continuous duty
and be inherently double throw. The switch shall be mechanically interlocked to ensure only one of two possible positions - normal or emergency. The automatic transfer switch shall be suitable for use with emergency sources such as engine or turbine generator source or another utility source.

C. The control module shall be supplied with a protective cover and be mounted separately from the transfer switch for ease of maintenance. Sensing and control logic shall be solid state and mounted on plug-in printed circuit boards. Printed circuit boards shall be keyed to prevent incorrect installation. Interfacing relays shall be industrial control grade, plug-in type with dust covers and locking clips. The following shall also be provided for the control module.

(1) For single phase switches, the normal source voltage across live lines shall be monitored, and for three phase switches all phases of the normal shall be monitored line-to-line. Close differential voltage sensing shall be provided on all phases. The pickup voltage shall be adjustable from 72% to 100% of nominal and the dropout voltage shall be adjustable from 72% to 98% of the pickup value. The transfer to emergency will be initiated upon reduction of normal source to 85% of nominal voltage and retransfer to normal shall occur when normal source restores to 95% of nominal.

(2) Neutral conductor terminal lugs as required for the system.

(3) All movable parts of the operating mechanism shall remain in positive mechanical contact with the main contacts during the transfer operation without the use of separate mechanical interlocks. Automatic operation of the switch shall not require power from any source other than the line-to-line voltage of the source to which the switch is transferring.

D. Switch Ratings:

(1) Refer to drawings for sizes.

(2) Manufacturer: Subject to compliance with requirements, automatic transfer switches shall be the same manufacturer as the generator.

(3) Each automatic transfer switch shall include the following standard accessories.

   a. (TDNE) Time delay on transfer from Normal to Emergency (adjustable 0 to 60 seconds).

   b. (TDES) Time delay on Engine Starting (factory set at 3 seconds).

   c. (TDEN) Time delay on transfer from Emergency to Normal adjustable 0-30 minutes).

   d. (TDEC) Time delay on engine cool-off.
e. Four position selector switch with white light. Permits four modes of switch operation -- TEST, AUTO, OFF, and ENGINE START.

f. Frequency/voltage relay for emergency source.

g. Disconnect plug on wiring harness to disconnect switch control logic.

h. Main shaft auxiliary contact rated 10 ampere at 480V (one closed on normal and one closed on emergency).

i. Green lamp to indicate switch in normal position and normal power is supplying loads.

j. Red lamp to indicate switch in emergency position and emergency power is supplying loads.

k. Provide switches with programmed transition. Switch shall be capable of manual transfer under full load.

l. Automatic exerciser shall be programmable for exact day and time regardless of the time it is being programmed.

1) Provide two auxiliary contacts, 300 volt, 20 A rated, on main shaft (closed normally)
2) Provide two auxiliary contacts, 300 volt, 20 A rated, on main shaft (closed on emergency)

(4) RACEWAYS

a. General: Provide raceways complying with Division-16 Basic Materials and Methods section "Raceways," in accordance with the following listing:

   UL Type THW or THHN, copper conductor.

(5) ELECTRICAL BOXES AND FITTINGS:

a. General: Provide electrical boxes and fittings complying with Division-16 Basic Materials and Methods section "Electrical Boxes and Fittings".

10. EXECUTION

A. INSTALLATION OF ENGINE GENERATOR SYSTEMS:

(1) Install standby engine generator sets as indicated, in accordance with the equipment manufacturer's written instructions, and with recognized industry practices, to ensure that engine generator sets fulfill requirements. Comply with NFPA and NEMA standards pertaining to installation of standby engine generator systems and accessories.
(2) Coordinate with other work, piping and accessories, as necessary to interface installation of standby generator system work with other work.

(3) Install units on vibration isolators in accordance with Division-15 section; comply with manufacturer's indicated installation method if any.

(4) Connect gas piping to standby generator equipment as indicated, and comply with manufacturer's instructions where not otherwise indicated. Piping to be painted.

(5) Align shafts of engine and generator within tolerances recommended by equipment manufacturer.

B. GROUNDING:

(1) Provide equipment grounding connections, sufficiently tight to assure a permanent and effective ground, for system components as indicated.

C. TESTING:

(1) Manufacturer shall provide a factory trained service engineer to supervise entire testing procedure.

(2) Upon completion of installation of engine generator system and after building circuitry has been energized with normal power source, test engine generator to demonstrate standby capability and compliance with requirements. Where possible, field correct malfunctioning units, then retest to demonstrate compliance; otherwise, replace defective components and proceed with retesting.

(3) Run generator under full load for a minimum of 4 hours and record results. Generator shall be capable of delivering full capacity while operating in an ambient temp. of 122 degrees F. Factory test data showing run-test loads is not acceptable. Resistive load tank shall be furnished and connected to the generator to achieve a full load per generator capacity. Generator shall be capable of delivering full capacity while operating in an ambient temperature of 122 degrees F. Factory test data showing run-test loads is not acceptable.

(4) Record Fuel consumption, coolant temperature, lube oil pressure, output voltage (each phase), output current (each phase), room temperature at 2 hour intervals.

(5) Verify motor starting ability by use of largest connected motor and the load bank.

(6) The complete automatic transfer switch shall be tested as to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency and time delay settings are in compliance with the specification requirements.
D. TRAINING OF OWNER'S PERSONNEL:

   (1) Provide services of manufacturer’s technical representative for 4-hours to instruct Owner's personnel in operation and maintenance of the engine generator system.

   (2) Schedule training with Owner, provide at least 7-day notice to Contractor and Engineer of training date. Obtain receipt that training has been accomplished.

E. 5-YEAR COMPREHENSIVE WARRANTY:

   (1) For standby power applications only, the complete electrical power system (generator set, controls and associated switches, switchgear and accessories), as provided by the single-source manufacturer, shall be warranted by said manufacturer against defects in materials and workmanship for a period of five years or 1500 hours, whichever occurs first from the Final Project Completion date of system start-up. Said coverage shall include parts, labor, travel expenses, and labor to remove/reinstall said equipment, per the manufacturer’s standard published limited warranty. There shall be no deductibles applied to said warranty.

END OF SECTION.
SECTION 16285 - SURGE SUPPRESSION SYSTEMS

1. GENERAL

A. Each Contractor's attention is directed to Section 16000, General Provisions-Electrical and all other contract documents as they may apply to his work.

B. Each Surge Suppression Unit (transient voltage surge suppressor, or T.V.S.S.) furnished shall meet or exceed U.L. 1449, Second Edition Revision (February 2007), with capacity for each basic Category A, B and C, surge rise time of ten microseconds and a surge duration of at least one thousand microseconds.

C. SPECIAL NOTE: When using a “Meggar” or similar instrument to test conductors in a panelboard or switchboard, disconnect any T.V.S.S. device connected to any combination of those conductors. Failure to do so may damage or destroy the T.V.S.S. device. If any damage occurs as a result of testing to a T.V.S.S. device, the Contractor shall replace the device.

2. SCOPE OF THE WORK

A. The Contractor shall provide the necessary labor, materials, wiring and services necessary to provide the complete electrical surge protection systems as specified herein. This work shall include, but is not necessarily limited to:

   (1) Provision of Surge Suppression Units at certain points in the power distribution network, on telephone, satellite dish leads and cable television service lines as indicated herein or on the drawings.

   (2) Proper installation of surge suppression unit(s), in accord with shop drawings. Wiring routing, grounding, raceways and all connections shall be in exact accord with manufacturer's recommendations, the National Electrical Code, and any other applicable regulations, local or national, or international.

3. QUALITY ASSURANCE

A. The manufacturer shall be regularly engaged in production of surge protection equipment, of types, sizes and ratings required, whose products have been satisfactorily used in similar service for not less than three years.

B. Comply with NEC and NFPA requirements, as applicable to materials and installation of surge protection components and wiring. Surge protection equipment shall be UL listed and labeled for its intended use. TVSS shall be labeled with 200kA Short Circuit Current Rating (SCCR). Where applicable, equipment shall comply with ANSI standards for such equipment.
C. SPECIAL NOTE: The physical routing, length and connections of the unit's phase, neutral and ground conductors are critical to the performance of surge suppression units. The Contractor shall carefully observe and comply with the manufacturer's installation requirements.

4. SUBMITTALS

A. Product Data: Submit manufacturer's data on surge protection systems and components as part of shop drawing submissions. Indicate all capacity ratings, clamp times, maximum capacities, EMI/RFI attenuation data, withstand capabilities, physical construction and listing agency approvals.

B. Maintenance Data: Submit maintenance instructions for surge suppression system. Include this data in Operation and Maintenance manuals.

5. MATERIALS

A. ACCEPTABLE MANUFACTURERS

Subject to compliance with requirements, manufacturers offering surge protection components which may be incorporated in the work includes, but are not limited to, the ones listed below. Other manufacturers will be considered if their proposed products are in full compliance with these specification requirements.

Surge Protective Devices:

Liebert Corporation, Inc
General Electric Corporation
Transtector, Inc.
Advanced Protection Technologies, Inc.
Square D. Inc.

6. T.V.S.S. MINIMUM REQUIREMENTS

T.V.S.S. minimum requirements shall meet or exceed the following criteria:

A. Minimum surge current capability (single pulse rated) per phase shall be:

   (1) Service entrance applications: 200 kA per phase (Category “C”)
   (2) Distribution applications: 120 kA per phase (Category “B”)
   (3) Non-receptacle applications: 40 kA per phase (Category “A”)
   (4) Receptacle applications: 12 kA per phase (Category “A”)

B. UL 1449 Listed Suppression Voltage Ratings for service entrance shall not exceed the following:
   (Category “C”)

   VOLTAGE   L-N   L-G   N-G   MCOV
(With internal disconnect switch 400V and 800V respectively).

C. UL 1149 Listed Suppression Voltage Ratings for distribution shall not exceed the following:

(Category “A” & “B”)

<table>
<thead>
<tr>
<th>VOLTAGE</th>
<th>L-N</th>
<th>L-G</th>
<th>N-G</th>
<th>MCOV</th>
</tr>
</thead>
<tbody>
<tr>
<td>208Y/120V</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>150V</td>
</tr>
<tr>
<td>240Delta/120V</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>150V</td>
</tr>
<tr>
<td>480Y/277V</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td>320V</td>
</tr>
</tbody>
</table>

(With internal disconnect switch 400V and 800V respectively)

(L-N = Line to neutral)
(L-G = Line to ground)
(N-G = Neutral to ground)
(MCOV = Maximum continuous operating voltage)

7. BUILDING ELECTRICAL SERVICE SURGE PROTECTION SYSTEM COMPONENTS

A. GENERAL

(1) Provide UL 1449 Second Edition Revision (February 2007) listed and labeled lightning and transient surge protection devices, installed where shown on the drawings and in accord with the manufacturer's recommendations.

(2) The surge protection devices shall be shunt type and polyphase, with the ability to conduct high energy transients from line to ground, line to neutral and neutral to ground. Provide in a NEMA 12 enclosure with hinged or screw cover front panel. Provide internal fusing in modules to protect unit.

(3) Provide units with EMI/RFI noise attenuation, using 50 ohm insertion loss test: -50 dB at 100 khz, UL 1283 listed, with an insertion ratio of 50:1 using M.I.L. STD 220-A.

(4) For each surge suppression unit, categories A, B & C, provide unit function status indicators. These indicators shall be mounted in the face of the equipment panel. Provide green L.E.D., illuminated for normal operation, red L.E.D. for trouble/fault or reduction of surge suppression capacity. Provide an audible alarm with silence switch to alarm at unit on malfunction for category "C" units only. Provide a resettable surge counter for each category "C" unit to indicate each suppression operation of the unit.
(5) Enclosures shall be surface-mounted where panels protected are surface-mounted, flush-mounted for all units in finished areas. Where panels protected are flush-mounted, place surge suppression device above or below panel, aligned and square with panel trim.

(6) Provide disconnecting means for each surge protection device per the following:

Category "C" Device at Main Service:
40 to 60 Ampere, 3 Pole, 600V, S/N, NEMA 1 disconnect, built into the unit and furnished by the supplier as an integral part of the equipment. Disconnecting means shall be capable of withstanding the available fault currents. Verify fault current with the Contractor.

Category "B" Devices, at Panels:
30 Ampere, 3 Pole Circuit Breaker in Protected Panel

Category "A" Devices, at Panels:
30 Ampere, 3 Pole Circuit Breaker in Protected Panel

(7) Internal Device Overcurrent Protection (Fusing)

a. All protection modes (including Neutral to Ground) of each surge suppression device shall be internally fused at the component level with fuse I²t capability allowing the suppressor's maximum rated transient current to pass through the suppressor without fuse operation. Every suppression component of every mode (including Neutral to Ground) shall also be protected by thermal overtemperature controls. If the rated I²t characteristic of the fusing is exceeded, the fusing shall be capable of opening in less than one millisecond and clear both high and low impedance fault conditions. The fusing shall be capable of interrupting up to 200 KA symmetrical fault current with 600 VAC applied. This overcurrent protection circuit shall be monitored, to provide indication of suppression failure. Conductor level fuses or circuit breakers internal or external to the surge suppression units are not acceptable as meeting this requirement.

B. MAIN SERVICE SURGE SUPPRESSION - CATEGORY "C" UNITS

(1) Category "C" units shall be installed as indicated on the contract documents. Units shall be rated 277 volts/480 volts (or 120/208 volts as needed), 3 phase, 4 wire, minimum 200,000 amp (total amps per phase) surge capacity, with less than 5 nanosecond reaction time. Category "C" units installed to protect a switchboard may be built into the switchboard construction if U.L listed for such applications.

(2) Category "C" withstand capabilities: 5,000 A.N.S.I. Category C3 surges with less than 10% change in clamping voltage.

C. PANELBOARD SURGE SUPPRESSION - CATEGORY "B" UNITS
(1) Units shall be installed as indicated on the contract documents, set beside or above the distribution panel indicated, and connected as recommended by the equipment manufacturer.

(2) Category "B" units shall be rated for 277-480 volts (or 120/208 volts, as indicated), 3-4 Wire Wye service. Units shall be minimum 120,000 ampere rated per phase, with less than 5 nanosecond reaction time. Provide fusing and fault indicator pilot lights as in (A) - General above.

(3) Category "B" withstand capabilities: 5,000 A.N.S.I. Category C3 surges with less than 10% change in clamping voltage.

D. BRANCH PANELBOARD SURGE SUPPRESSION - CATEGORY "A" UNITS (NON-RECEPTACLE APPLICATIONS)

(1) Units shall be installed flush in finished areas. Units may be surface-mounted if in unfinished mechanical spaces and the panel protected is also surface-mounted. Locate as indicated on the contract documents and connect in exact accord with the manufacturer's recommendations. They shall be rated 40,000 amperes surge current, less than one nanosecond response time.

(2) Category "A" units shall be rated for 277/480 volts or 120/208 volts, three phase, 4 wire wye service as indicated on the drawings. Units shall be fused in accord with (A) - General noted above.

(3) Furnish unit with red and green indicator lights to signify normal operation and component or suppression capability failure.

E. TELEPHONE AND TELEVISION SURGE SUPPRESSION

(1) As a part of this section of work, the Contractor shall provide or arrange for the installation of U.L. listed lightning and surge arrestors on the incoming telephone and television service lines, as well as on AM-FM- antenna downleads and the coaxial cables coming into the building from satellite dish antennas and all other types of exterior antennas installed by the Contractor or Owner, where the Contractor installs the coaxial cable for the antenna.

(2) Arrestors shall be U.L. listed, properly grounded per N.E.C., and shall be located at the service entrance points for each cable installed by a utility company or at the point of building entry for Contractor-installed cables leading in from antennas. Also provide surge arrestors of the proper type for any copper cables that are installed between buildings by the Contractor, if such a condition occurs within the project.

(3) The Contractor shall arrange for the telephone company to install M-O-V, gas-type or other U.L. listed lightning arrestors on each of their incoming telephone circuits that are terminated for building use.
(4) Arrestors for coaxial lines shall be rated 25 to 250 MHZ on cable T.V. lines, and 250 MHZ to 1GHZ on satellite dish lead-ins with BNC jacks in/out or as required by antenna connectors.

(5) Devices as manufactured by Lucent Technologies, Winegard or Liebert Corporation will be acceptable.

(6) Provide a ground lug for individual surge suppression unit installations, with the recommended ground wire size routed back to the building main electrical ground or ground bar in wiring closet.

(7) Where multiple surge suppression units are installed, as at service entrance locations, provide a ground bar, copper, with multiple tapped holes and a properly sized ground lead routed back to the building main electrical ground.

8. EXECUTION

A. Installation of Surge Protection Systems:

(1) Install surge protection systems as indicated and in accordance with equipment manufacturer's written instructions, in compliance with applicable requirements of NFPA, local prevailing codes and with UL lightning and power surge protection standards to ensure that surge suppression systems comply with requirements.

(2) Coordinate with other work, including electrical wiring work as necessary to interface installation of units.

(3) Install conductors with direct, shortest possible phase, neutral and ground paths from all in/out connections, avoiding sharp bends and narrow loops.

(4) Install surge suppression units as close as practical to equipment they are protecting. Install appropriate units at main electrical service entrance equipment and secondary branch panelboards as indicated.

(5) Refer to the drawings for installation of individual surge suppression devices to protect branch circuits. Also see Section 262726 for (receptacle type) device requirements. All receptacle type surge suppression units shall be wired as feed-thru type, to protect all downstream outlets on that branch circuit unless otherwise indicated.

9. WARRANTIES

A. All surge suppression equipment shall be unconditionally warrantied by the Contractor for a period of one year from the date of project substantial completion. Where longer manufacturer's warranties are offered, they shall be made available to the Owner. Note these extended warranties in the Operations and Maintenance Manuals.
B. Category "C" devices to carry 5 year parts and on site labor unconditional warranty.

C. Category "B" and "A" devices to carry 5 year unconditional replacement warranty.

END OF SECTION.
SECTION 16400 - ELECTRICAL DISTRIBUTION EQUIPMENT

1. GENERAL

A. All electrical distribution equipment shall be dead front UL listed for the purpose and application. All equipment shall meet or exceed all applicable requirements of the National Electrical Code (N.E.C.). Any device or component, i.e., switchboard, panel, breaker, switch, etc., used as service entrance equipment, shall be listed for use at 100% of the rated capacity. All work shall be approved by the Authority Having Jurisdiction.

2. MAIN SWITCHBOARD - CIRCUIT BREAKER STYLE

A. Switchboard shall be dead front, totally enclosed, free standing or wall mounted, as required or herein specified, housing the equipment as indicated. The switchboard shall meet Underwriters' Laboratories enclosure requirements, and be furnished with an Underwriters' Laboratories label. The entire switchboard is to be Square D I-Line or equivalent construction, G.E., Siemens, Eaton / Cutler - Hammer or approved equivalent. Where switchboards are floor-mounted, provide concrete housekeeping pad, 3" high, with #4 rebar on 6" X 6" centers, per A.C.I. standards. Chamfer edges of pad 1/2".

B. The switchboard shall be dead-front with front accessibility. The switchboard framework shall consist of steel channels bolted to the frame to rigidly support the entire shipping section for moving on rollers and floor mounting. The framework is to be formed of code gauge steel, rigidly welded together to support all cover plate, bussing and component devices. All unused positions shall have closures.

C. Each switchboard section shall have an open bottom (closed for wall-mounted style) and a top plate for installation and termination of conduit. Top and bottom conduit areas are to be clearly shown and dimensioned on the shop drawings. The wireway front covers shall be secured by screws and hinged, to permit access to the branch circuit breaker load side terminals. The paint finish shall be medium light gray, per ANSI #49, applied by the electro-deposition process over an iron phosphate pre-treatment. Enclosure shall be NEMA 1, with drip shield on top. Provide top covers without knockouts. All conduit entries to be field cut. At top conduit entries, provide weatherproof sealing lock nuts on terminator.

D. The switchboard bussing shall be of sufficient cross-sectional area to meet UL Standard 891 on temperature rise. Main and/or through busses shall be 100% annealed copper. The through bus shall have an ampacity in amperes as indicated on the drawings and shall be braced to have a short circuit current rating of 100,000 RMS symmetrical amperes unless otherwise indicated. (Where through bus is provided, it shall have provisions for the addition of future sections on the branch or distribution side.) The through bus supports, connections and joints are to be bolted with hex head bolts and belleville washers to minimize maintenance requirements.

E. Neutral bussing shall be of the same ampacity bussing and insulated from the enclosure. Ground bussing shall be sized and shall be bonded to the enclosure per N.E.C., current edition. Service
grounding electrode connection shall be made between ground and neutral busses. Provide ground bushings and equipment ground conductor connection on each feeder conduit leaving switchboard and at the terminal end for each continuous metallic feeder conduit.

F. Each switchboard, as a complete unit, shall be given a single short circuit current rating by the manufacturer. Such a rating shall be established by actual tests by the manufacturer, in accordance with UL specifications, on equipment constructed similarly to the subject switchboard.

G. The service disconnect device(s) shall be thermal-magnetic molded case circuit breaker(s) installed totally front accessible and front connectable. Line side of branch circuit breaker connections are to be jaw type plug-on. Ground fault protection shall be provided as required by N.E.C. Article 230-95, where switchboard is rated for 277/480 volts and circuit breaker frame sizes are 1000 amperes or greater, regardless of trip setting.

H. Group mounted molded case circuit breakers for branch distribution are to be totally front accessible. These circuit breakers are to be mounted in the switchboard to permit installation, maintenance and testing without reaching over any line side bussing. The circuit breakers are to be removable by the disconnection of only the load side cable terminations. All line and load side connections are to be individual to each circuit breaker. Common mounting brackets or electrical bus connectors will not be acceptable. Line side circuit breaker connections are to be jaw type plug-on, arranged to withstand the anticipated fault currents.

I. Each circuit breaker is to be furnished with an externally operable mechanical means to trip the circuit breaker, enabling maintenance personnel to verify the ability of the circuit breaker trip mechanism to operate as well as exercise the circuit breaker operating mechanisms.

J. Include kw, kwh, voltage, amperage metering per phase along with appropriate digital output to interface with campus DDC control system for remote monitoring of power system. Coordinate with controls supplier for a 100% complete installation.

K. All circuit breakers shall have a minimum ISCA rating of 65,000 amps, A.I.C., unless otherwise noted on the One-Line Diagram.

L. Provide an arc energy reducing maintenance switch with local status indicator for all breakers or equipment rated or adjustable to 1,200 Amps or greater. Provide a local status indicator light for all breakers equipped with maintenance switches. Maintenance switch and indicator shall be mounted to the breaker face or immediately adjacent to the breaker in the switchboard enclosure. Maintenance switch shall have permanently mounted lockout/tagout provisions. Provide labelling to indicate operation instructions for maintenance switch at each switch.

M. Arc Flash Hazard warning labels shall be affixed to all switchboards in accordance with Article 110.16 of the National Electrical Code. All components protected by a manually-operated arc energy reduction means shall have an additional label affixed that describes the location of the energy reduction means.
N. Switchboard shall be Square "D", G.E., Siemens, Eaton/Cutler–Hammer or approved equivalent.

O. Lockable breakers shall be provided for all breakers serving all HVAC equipment, Plumbing equipment, and kitchen appliances.

3. DISTRIBUTION PANELBOARDS (600 AMPERE OR GREATER)

A. Panelboard assembly shall be enclosed in a steel cabinet. The rigidity and gauge of steel to be as specified in UL Standard 50 for cabinets. The size of wiring gutters shall be in accordance with UL Standard 67. Cabinets to be equipped with latch and tumbler-type lock on door of trim. Doors over 48" long shall be equipped with three-point latch and vault lock. All locks shall be keyed alike. End walls shall be removable. Fronts shall be of code gauge steel, with gray baked enamel finish electrodeposited over cleaned, phosphatized steel.

B. The panelboard interior assembly shall be dead front with panelboard front removed. Main lugs or main breakers shall have barriers on five sides. The barrier in front of the main lugs shall be hinged to a fixed part of the interior. The end of the bus structure opposite the mains shall have barriers. Bus structure shall be full height of panel.

C. Panelboard bus structure and main lugs or main breaker shall have current ratings as shown on the panelboard schedule. Such ratings shall be established by heat rise tests with maximum hot spot temperature on any connector or bus bar not to exceed 50ºC. rise above ambient. Heat rise tests shall be conducted in accordance with Underwriters Laboratories Standard UL 67. The use of conductor dimensions will not be accepted in lieu of actual heat tests. All panelboards unless otherwise noted shall have space to accept forty-two 20 amp one pole circuit breakers.

D. Circuit breakers shall be equipped with individually insulated, braced and protected connectors. The front faces of all circuit breakers shall be flush with each other. Large, permanent, individual circuit numbers shall be affixed to each breaker in a uniform position. Tripped indication shall be clearly shown by the breaker handle taking a position between "ON" and "OFF." Provisions for additional breakers shall be such that no additional connectors will be required to add breakers. All panelboards shall be capable of accepting 225 amp 3 pole branch breakers as a minimum unless otherwise noted.

E. Each panelboard, as a complete unit, shall have a short circuit current rating equal to or greater than the integrated equipment rating shown on schedules on the plans or as determined by verification with local utility company. This rating shall be established by testing with the overcurrent devices mounted in the panelboard. The short circuit tests on the overcurrent devices and on the panelboard structure shall be made simultaneously by connecting the fault to each overcurrent device with the panelboard connected to its rated voltage source. Method of testing shall be per Underwriters Laboratories Standard UL 67. The source shall be capable of supplying the specified panelboard short circuit current or greater. Testing of panelboard overcurrent devices for short circuit rating only while individually mounted is not acceptable. Also, testing of the bus structure by applying a fixed fault to the bus structure alone is not
accept. Panelboards shall be marked with their maximum short circuit current rating at the supply voltage and shall be UL listed.

F. Arc Flash Hazard warning labels shall be affixed to all panelboards in accordance with Article 110.16 of the National Electrical Code. All components protected by a manually-operated arc energy reduction means shall have an additional label affixed that describes the location of the energy reduction means.

G. Distribution panelboards shall be Square "D", G.E., Siemens, Eaton/Cutler–Hammer or approved equivalent.

H. Lockable breakers shall be provided for all breakers serving all HVAC equipment, Plumbing equipment, and kitchen appliances.

4. BRANCH PANELBOARDS

A. This section covers lighting and power panelboards (refer to schedules, notes on Drawings and the Electrical One-Line Diagram, of the Contract Drawings).

B. All panelboards shall be of the circuit breaker type, and shall be of one manufacturer.

C. Branch panelboards shall be as indicated on the drawings and as specified herein. The lighting panelboards shall be of the dead-front, quick-make, quick-break, plug-in circuit breaker type, with trip indicating and trip free handles. All circuits shall be clearly and properly numbered and shall be provided with thermal magnetic protection. The panelboards shall be enclosed in code gauge, galvanized steel cabinets with smooth finished hinged doors without visible external fasteners and heavy chrome locks. Locks shall all be keyed alike. Each door shall have a directory card inside, covered with a plastic shield, filled in with black india ink or typewritten with circuit numbers and description indicated. Room numbers shall be coordinated with final room numbers as selected by Owner -- not numbers on Contract Documents.

Special Note: The room numbers used to fill out the panel directories shall match the actual final name and numbering scheme selected by the Owner. They shall not be filled out per the construction drawing numbering scheme, unless the Contractor is directed to do so by the Architect or Engineer.

D. Branch panelboards shall be surface or flush mounted as indicated on the Contract Drawings.

E. Circuit breakers for 120/208 volt systems shall be of 10,000 A.I.C. RMS symmetrical rating unless otherwise indicated on the Contract Drawings. For 277/480 volt systems, provide circuit breakers with 14,000 A.I.C. ratings unless otherwise indicated.

F. All main bus and connections thereto in branch panelboards shall be copper. All bus bars shall extend full length of panelboards.
G. All circuit breakers used to switch lights shall be SWD (switching duty) rated and U.L. listed for the purpose.

H. Where required by the National Electrical Code, provide branch arc-fault circuit interrupters (A.F.C.I.’s) in branch panelboards, whether indicated on the panel schedule or not. They shall be U.L. listed, latest edition.

I. Where branch circuit breakers feed hermetically, sealed compressor for cooling or refrigeration equipment, provide U.L. listed H.A.C.R.-style circuit breakers.

J. Where branch circuit breakers are indicated or required to be ground-fault circuit-interrupting type (G.F.C.I.), they shall have test and reset buttons and be U.L. listed, latest edition. Do not share neutrals with other circuits.

K. Where branch circuit breakers are feeding H.I.D. (high-intensity-discharge) loads, they shall be rated and listed for such loads. Provide proper circuit breaker whether indicated on panel schedules or not.

L. Arc Flash Hazard warning labels shall be affixed to all panelboards in accordance with Article 110.16 of the National Electrical Code. All components protected by a manually-operated arc energy reduction means shall have an additional label affixed that describes the location of the energy reduction means.

M. Panels shall be Square "D", G.E., Siemens, Eaton/Cutler-Hammer or approved equivalent.

N. Lockable breakers shall be provided for all breakers serving all HVAC equipment, Plumbing equipment, and kitchen appliances.

5. INSTALLATION INSTRUCTIONS

A. Panelboards with circuit breakers installed before the building has been finished and cleaned shall be masked.

B. All dust and debris shall be removed from the panels before they are energized and placed in service.

C. All panelboard fronts shall be omitted until final punch list inspection is made. Directories for each panelboard shall be completed and available for review by the Engineer at that time.

6. SAFETY SWITCHES

A. Provide heavy duty safety switches as a final disconnecting means as required by NEC and/or as indicated on the Contract Drawings.

B. All safety switches shall be NEMA Type 1, NEMA 3R, NEMA 4 stainless steel, NEMA 12, or as required by the operating environment, Heavy Duty Type HD, UL listed.
C. All safety switches shall have switch blades that are fully visible in the "OFF" (open) position with the door open.

D. All current carrying parts shall be plated by an electrolytic process to resist corrosion and to promote cooling.

E. Switch mechanism shall be quick-make, quick-break, load break rated, such that during normal operation of the switch, the operation of the contacts shall not be capable of being restrained by the operating handle after the closing and opening action of the contacts has started. The handle and mechanism shall be an integral part of the box (not cover) with facilities for pad locking in the open or closed position with up to three padlocks. Switch doors shall be interlocked with switch handle so that the door can only be opened when the switch is in the "OFF" (open) position.

F. Arc Flash Hazard warning labels shall be affixed to all switches in accordance with Article 110.16 of the National Electrical Code. All components protected by a manually-operated arc energy reduction means shall have an additional label affixed that describes the location of the energy reduction means.

G. Switches shall be as manufactured by Square D., G.E., Siemens, Eaton/Cutler-Hammer or approved equivalent.

7. FUSES

A. Upon completion of the building, the Contractor shall provide the owner with spare fuses as shown below. All fuses shall be Bussmann, Shawmut, Gould or Reliance.

(1) 10% (minimum of 3) of each type and rating of installed fuses shall be supplied as spares:

(2) Bussmann spare fuse cabinets - Catalog No. SFC - shall be provided to store the above spares.

B. No fuses shall be installed in the equipment until the installation is complete, including tests and inspections required prior to being energized. All fuses shall be of the same manufacturer to insure retention of selective coordination, as designed.

C. Circuits 601 to 6000 amperes shall be protected by current limiting BUSSMANN HI-CAP TIME DELAY FUSES KRP-C. Fuses shall employ "O" rings as positive seals between the end bells and the fuse barrel. Fuses shall be a time-delay type and must hold 500% of rated current for a minimum of 5 seconds, clear 20 times rated current in .01 seconds or less and be listed by Underwriter's Laboratories, Inc., with an interrupting rating of 200,000 amperes R.M.S. symmetrical. The fuses shall be UL Class L.

D. Circuits 0 to 600 amperes shall be protected by current limiting BUSSMANN LOW-PEAK Dual Element Fuses, LPN-RK (250 volts) or LPS-RK (600 volts). All dual element fuses shall have
separate overload and short circuit elements. Fuse shall incorporate a spring activated thermal overload element having a 284°F melting point alloy and shall be independent of the short-circuit clearing chamber. The fuse shall hold 500% of rated current for a minimum of 10 seconds and be listed by Underwriters Laboratories, Inc. with an interrupting rating of 200,000 amperes r.m.s. symmetrical. The fuses shall be UL Class RK1.

E. Motor Circuits - All individual motor circuits rated 480 amperes or less shall be protected by BUSSMANN LOW PEAK DUAL-ELEMENT FUSES LPN-RK (250 volts) or LPS-RK (600 volts). The fuses for 1.15 service factor motors shall be installed in rating approximately 125% of motor full load current except where high ambient temperatures prevail, or where the motor drives a heavy revolving part which cannot be brought up to full speed quickly, such as large fans. Under such conditions the fuse should be 150% to 200% of the Type KRP-C HI-CAP Time Delay Fuses of the rating shown on the drawings. 1.0 service factor motors shall be protected by BUSSMANN LOW-PEAK Dual Element Fuses LPN-RK (250 volts) or LPS-RK (600 volts) installed in rating approximately 115% of the motor full load current except as noted above. The fuses shall be UL Class RK1 or L.

F. Circuit breaker panels shall be protected by BUSSMANN LOW-PEAK Dual Element fuses LPN-RK (250 volts) or LPS-RK (600 volts) as shown on the drawings. The fuses shall be UL Class RK1.

8. CONTACTORS

A. General

(1) Contactors shall be continuously rated at the specified amperes per pole for all types of ballast and tungsten lighting, resistance and motor load. Contactors shall have totally enclosed, double-break silver-cadmium-oxide power contacts. Auxiliary arcing contacts will not be acceptable. Contact inspection and replacement shall be possible without disturbing line or load wiring. Contactors shall have straight-through wiring with all terminals clearly marked. Contactors shall have a gasketed NEMA Type 1 (NEMA 12 for electrically-held) enclosure, unless otherwise noted or required.

(2) Contactors shall be approved per UL 508 and/or CSA, and be designed in accordance with NEMA Standards. They shall be industrial-duty rated for applications to 600 volts maximum. I.E.C.-style contactors are not acceptable.

(3) Contactors shall have provisions for factory or field addition of:

   a. Four N.O. or N.C. auxiliary contacts rated 6 amperes continuous at 600 volts.

   b. Single or double circuit, N.O. or N.C., 30 or 60 ampere 600 volt power-pole adder.

   c. Control-circuit fuse holder, one or two fuses.

   d. 0.2-60 second adjustable interval timer attachment, if so indicated on plans.
e. Transient-suppression module for coil control circuit. Coil control to be 120 volts. Provide circuit or step-down transformer.

B. Electrically Held Lighting Contactors

(1) Contactor coils shall be continuously rated and encapsulated, 120 volt rated. Enclosures shall be NEMA 12, to minimize noise transmission.

C. Mechanically Held Lighting Contactors

(1) Coil-clearing contacts shall be supplied so that the contactor coils shall be energized only during the instance of operation. Both latch and unlatch coils shall be encapsulated. Coils shall be rated for 120 volt operation.

(2) Lighting contactors shall be Square D Class 8903 or equivalent by G.E., Siemens, Eaton/Cutler-Hammer or Allen-Bradley.

END OF SECTION.
SECTION 16410 - ELECTRICAL STUDIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. All services, materials and installation shall comply with the owners’ construction standards. Special attention shall be given to Divisions 02, 16 and 17. In the event of a conflict between these standards and the Contract Documents the most stringent requirement shall be met.

C. The Contractor is directed to examine each and every section of these specifications, all drawings relating to the Contract Documents, any and all Addenda, etc., for work described elsewhere that may relate to the provision of the work described herein. Materials and performance requirements are specified elsewhere herein that relate to these systems.

D. Each Electrical Contractor's attention is directed to Section 260501 - General Provisions, Electrical, and all other Contract Documents as they apply to his work.

1.2 SUMMARY

A. This Section includes computer-based, fault-current, arc flash and overcurrent protective device coordination studies. Protective devices shall be set based on results of the protective device coordination study.

B. Electrical Studies shall be performed by the Low-Voltage Switchboard manufacturer. All Electrical Studies required by this specification shall be completed within five (5) weeks from award of project. The Electrical Contractor shall provide all required data to Low-Voltage Switchboard manufacturer within one (1) week and the manufacturer will have four (4) weeks to complete the studies.

C. A licensed professional engineer employee of the Low-Voltage Switchboard manufacturer shall provide electrical power system studies for the project using the latest version of one of the approved software packages. The software model files shall be submitted with the report. The analysis shall follow the latest IEEE 1584 guidelines. An example report will be provided by the university upon request.

D. Studies specified herein must be submitted and approved prior to release of any affected equipment. Revisions to equipment or devices necessary to meet study recommendations shall be at the Manufacturer’s expense.

E. All adjustments and settings recommended by these studies shall be made prior to any testing.

F. The analysis shall be submitted to the engineer of record prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing.

1.3 SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

C. Qualification Data: For coordination-study specialist.
D. Other Action Submittals: The following submittals shall be made after the approval process for system protective devices has been completed. Submittals shall be in digital form.

1. Coordination-study input data, including completed computer program input data sheets.
2. Study and Equipment Evaluation Reports.

E. Owners Record Copy: The as-built software model and all electronic files are to be provided to the owner at project closeout. Electronic files are to be compatible with the latest version of SKM software. The owner shall receive rights to use and/or modify the electronic files and data for operations planning, maintenance and modification of their electrical system.

1.4 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Coordination-Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. Professional engineer, licensed in the state where Project is located, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of engineer.

C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

1.5 Commissioning

A. This section specifies a system or a component of a system being commissioned as defined in Section 019113 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 019113 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Computer Software Developers: Software utilized shall be capable of converting all data to SKM formatting. Subject to compliance with requirements, provide products by one of the following:

1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. Operation Technology, Inc.
5. SKM Systems Analysis, Inc.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance.

3.2 POWER SYSTEM DATA

A. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.

2. Impedance of utility service entrance.

3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:
   a. Circuit-breaker and fuse-current ratings and types.
   b. Relays and associated power and current transformer ratings and ratios.
   c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
   d. Generator kilovolt amperes, size, voltage, and source impedance.
   e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
   f. Busway ampacity and impedance.
   g. Motor horsepower and code letter designation according to NEMA MG 1.

4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
   a. Special load considerations, including starting inrush currents and frequent starting and stopping.
   b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
   c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
   d. Generator thermal-damage curve.
   e. Ratings, types, and settings of utility company's overcurrent protective devices.
   f. Special overcurrent protective device settings or types stipulated by utility company.
   g. Time-current-characteristic curves of devices indicated to be coordinated, including arc-reduction features where applicable.
   h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.

j. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

B. Data shall be obtained for the power sources (utility system and generators), impedance components (transformers, cables and busway), overcurrent protective devices (fuses, circuit breakers and relays) and other relevant equipment such as automatic transfer switches. Cable data (length, quantity per phase, size and type) shall be provided by the electrical contractor. Assumptions should only be used when the actual data is not available and the assumptions should be clearly listed in the report. Assumptions shall be kept to a minimum.

C. A one-line diagram shall be provided as part of the analysis and shall clearly identify individual equipment buses, bus numbers used in the analysis, cable information (length, quantity per phase, size and type), overcurrent device information (manufacturer, type and size), transformers, motors, transfer switches, generators, etc.

D. The one line and analysis shall use a numbering scheme where each bus begins with a three digit number followed by a description (e.g., 102 MDPA or 103 ELEV DISC) and each connected circuit breaker or fuse shall have a corresponding designation (e.g., 102-1 MAIN CB, 102-2 ELEVATOR FDR or 103-1 ELEV DISC CB).

3.3 FAULT-CURRENT STUDY

A. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit-breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:

1. Switchgear and switchboard bus
2. Medium-voltage switch and transformers
3. Distribution panelboards
4. Branch circuit panelboards
5. Variable Frequency Drives
6. Motor Control Centers
7. Company switches
8. Fused and non-fused disconnects
9. Low-voltage transformers
10. Individual circuit breakers
11. Automatic transfer switches
12. Generator
13. Combination starter/disconnects

B. Study electrical distribution system from normal and alternate emergency power sources throughout electrical distribution system for Project, using approved computer software program. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 241 and IEEE 242.

1. Transformers:
   a. ANSI C57.12.10
b. ANSI C57.12.22
c. ANSI C57.12.40
d. IEEE C57.12.00
e. IEEE C57.96

3. Low-Voltage Fuses: IEEE C37.46.

E. Study Report: Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.

F. Equipment Evaluation Report:
   1. For overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
   2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
   3. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

G. A table shall be included which lists the calculated short-circuit currents (rms symmetrical three phase), equipment short-circuit interrupting or withstand current ratings, and notes regarding the adequacy or inadequacy of the equipment at each bus.

H. Any inadequacies shall be called to the attention of the engineer of record and recommendations made for improvements as soon as they are identified.

3.4 COORDINATION STUDY

   1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
   2. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short-circuit currents.
   3. Calculate the maximum and minimum ground-fault currents.

B. Comply with IEEE 242 recommendations for fault currents and time intervals.

C. Transformer Primary Overcurrent Protective Devices:
   1. Device shall not operate in response to the following:
      a. Inrush current when first energized.
      b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
      c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
   2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

D. Motors served by voltages more than 600 V shall be protected according to IEEE 620.
E. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

F. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
   a. Device tag.
   b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
   c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
   d. Fuse-current rating and type.
   e. Ground-fault relay-pickup and time-delay settings.

2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
   a. Device tag.
   b. Voltage and current ratio for curves.
   c. Three-phase and single-phase damage points for each transformer.
   d. No damage, melting, and clearing curves for fuses.
   e. Cable damage curves.
   f. Transformer inrush points.
   g. Maximum fault-current cutoff point.

G. Completed data sheets for setting of overcurrent protective devices.

H. A table shall be included which lists the recommended settings of each circuit breaker and relay.

I. A sufficient number of log-log plots shall be provided to indicate the degree of system protection and coordination by displaying the time-current characteristics of series connected overcurrent devices and other pertinent system parameters.

J. Deficiencies in protection and/or coordination shall be called to the attention of the engineer of record and recommendations made for improvements as soon as they are identified.

K. The electrical engineer that performed the study shall be responsible to set the circuit breakers according to the analysis once the report has been approved by the engineer of record.

3.5 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2004, Annex D.

B. The analysis shall consider multiple possible utility scenarios as well as multiple system configurations where appropriate such as normal and emergency transfer switch positions and different main-tie-main configurations. Where manually activated arc energy reduction means
are utilized, the analysis shall calculate energy available downstream for normal operation and for maintenance mode operation.

C. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system. This includes all switchboards, switchgear, motor-control centers, panelboards, busway and splitters.

D. Safe working distances shall be based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm$^2$.

E. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not taken into consideration when determining the clearing time when performing incident energy calculations.

F. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment locations. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.

G. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows:
   1. Fault contribution from induction motors should not be considered beyond 3-5 cycles.
   2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g. contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

H. For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.

I. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.

J. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.

K. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

L. Incident energy and flash protection boundary calculations
   1. Arcing fault magnitude
2. Protective device clearing time
3. Duration of arc
4. Arc flash boundary
5. Working distance
6. Incident energy
7. Hazard Risk Category
8. Recommendation for arc flash energy reduction

M. The Arc Flash Hazard Analysis shall include recommendations for reducing Arc Flash Incident Energy (AFIE) levels and enhancing worker safety.

N. Results of the Arc Flash Hazard Analysis shall be submitted in tabular form and shall include the following information for each bus location: bus name, protective device name, bus voltage, bolted fault, arcing fault, trip/delay time, equipment type, working distance, arc flash boundary, incident energy and protective clothing category.

3.6 ARC FLASH WARNING LABELS

A. Arc flash labels shall be furnished and installed by the contractor of the Arc Flash Hazard Analysis.

B. The labels shall be 4 inches high by 6 inches wide and printed on a Brady THTEL-25-483-1-WA label type or similar. The arc flash label shall be as required by NFPA 70E or as required by the owner’s standards.

C. After labels will be based on recommended overcurrent device settings and will be provided after the results of the analysis have been presented to the owner and after any system changes, upgrades or modifications have been incorporated in the system.

3.7 Labels shall be machine printed, with no field markings.

3.8 Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings. Provide one arc flash label for all electrical equipment including:

A. For each 480 and applicable 208 volt panelboard, one arc flash label shall be provided.
B. For each 480 and applicable 208 volt distribution panelboard, one arc flash label shall be provided.
C. For each motor control center, one arc flash label shall be provided.
D. For each low-voltage switchboard, one arc flash label shall be provided.
E. For each switchgear, one flash label shall be provided.
F. For medium voltage switches and transformers, one arc flash label shall be provided.
G. For each fused or non-fused disconnect switch, one arc flash label shall be provided.
H. For each generator and automatic transfer switches, one arc flash label shall be provided.
I. For each variable frequency drives, one arc flash label shall be provided.
J. For each combination starter/disconnects, one arc flash label shall be provided.
K. For each fused or non-fused disconnect switch and individual circuit breakers, one arc flash label shall be provided.
L. For each low-voltage transformer, one arc flash label shall be provided.
M. For each company switch, one arc flash label shall be provided.

END OF SECTION 16410
SECTION 16500 - LIGHTING FIXTURES AND LAMPS

1. GENERAL

A. Furnish and install all lighting fixtures, as herein specified, complete with accessories for safe and effective operation. All fixtures shall be installed and left in an operable condition with no broken, damaged or soiled parts.

B. All items furnished shall comply with the latest standards applicable such as U.L., NEMA, etc., and shall bear labels accordingly. All fixtures shall be the color specified or as selected by the Architect. Wherever fixtures have evident damage, they shall be restored to new condition or shall be replaced. Likewise, fixtures showing dirt, dust or fingerprints shall be restored to new condition or shall be replaced.

C. Eight copies of light fixture factory shop drawings and cuts, showing fixture dimensions, photometric data, installation data and, if applicable, air handling data, shall be submitted to the Engineer for written approval 30 days after bid date. (Verify shop drawing quantities with the Architect.)

D. Locate pendant, surface mounted or chain-hung industrial fixtures in mechanical rooms and similar spaces to avoid ductwork and piping. Locate around and between equipment to maximize the available light. Request a layout from the Engineer if uncertain about an installation.

E. Alternate fixtures may be substituted for types specified by name or catalog number. Proposed substitutions must be submitted to the Engineer ten working days prior to bid date for written approval to bid. This written approval will only be issued in addendum form.

F. Where emergency battery packs are provided with fixtures (if any), they shall be connected to an unswitched power line and wired in accord with the manufacturer's recommendations. Battery packs shall have capacities for continuous operation per applicable codes. Test buttons and indicator lamps shall be visible and accessible with fixture door open, or shall be remotely flush mounted in the ceiling adjacent to the fixture.

G. Where remote emergency lighting transfer relays are provided, they shall be flush mounted in the ceiling adjacent to a controlled fixture. They shall be connected to an unswitched power line and installed in accord with the manufacturer's recommendations. Test buttons and indicator lamps shall be visible and accessible without removing ceiling tiles or access panels.

H. All reflecting surfaces, glass or plastic lenses, downlighting Alzak cones and specular reflectors shall be handled with care during installation to avoid fingerprints or dirt deposits. It is preferred that louvers be shipped and installed with clear plastic bags to protect louvers. At close of project, and after construction air filters are changed, remove bags. Any louver or cone showing dirt or fingerprints shall be cleaned with solvent recommended by the manufacturer to a like-new condition, or replaced as necessary in order to turn over to the Owner new fixtures at beneficial occupancy.
I. Refer to architectural details as applicable for recessed soffit fixtures or wherever fixture installations depend upon work of other trades. Coordinate all installations with other trades. Verify dimensions of spaces for fixtures, and if necessary, adjust lengths to assure proper fit and illumination of diffuser and/or area below.

J. Warranty shall start at Final Project Completion.

2. VOLTAGE

A. All lighting fixtures will be rated 120, 277 or 480 volts, single phase as indicated or required.

3. LED FIXTURES

LED SOURCES

A. LED’s shall be manufactured by a manufacturer who has produced commercial LEDs for a minimum of five (5) years.

B. Lumen Output – minimum initial delivered lumen output of the luminaire shall be as follows for the lumens exiting the luminaire in the 0-360 degree zone - as measured by IESNA Standard LM-79-08 in an accredited lab. Exact tested lumen output shall be clearly noted on the shop drawings.

C. Lumen output shall not decrease by more than 20% over the minimum operational life of 50,000 hours at the rated ambient operating temperature.

D. Individual LEDs shall be connected such that a catastrophic loss or the failure of one LED will not result in the loss of the entire luminaire.

E. LED Boards shall be suitable for field maintenance and have with plug-in connectors. LED boards shall be upgradable.

F. Light Color/Quality:
   (1) Correlated Color temperature (CCT) range as per specification, between 3000K, 3500K and 4000K shall be correlated to chromaticity as defined by the absolute (X,Y) coordinates on the 2-D CIE chromaticity chart.
   (2) Color shift over 6,000 hours shall be <0.007 change in u’ v’ as demonstrated in IES LM80 report.
   (3) The color rendition index (CRI) shall be 80 or greater
   (4) LED boards to be tested for color consistency and shall be within a space of 2.5 MacAdam ellipses on the CIE chromaticity chart.

LED DRIVERS

A. Driver: Acceptable manufacturer: eldoLED, Sylvania, or Philips that meet or exceed the criteria herein.

B. Ten-year expected life while operating at maximum case temperature and 90 percent non-condensing relative humidity.

C. Driver should be UL Recognized under the component program and shall be modular for simple field replacement.
D. Electrical characteristics: 120 – 277 volt, UL Listed, CSA Certified, Sound Rated A+. Driver shall be > 80% efficient at full load across all input voltages. Input wires shall be 18AWG solid copper minimum.

E. Dimming: Driver shall be suitable for full-range dimming. The luminaire shall be capable of continuous dimming without perceivable flicker over a range of 100 percent to 0.1 percent of rated lumen output with a smooth shut off function.

F. Dimming shall be controlled by a 0-10V signal, or if require “DMX”.

G. Driver shall include ability to provide no light output when the control signal drops below 0.5 V, and shall consume 0.5 watts or less in this standby.

H. Driver shall be capable of configuring a linear or logarithmic dimming curve.

I. Drivers shall track evenly across multiple fixtures at all light levels, and shall have an input signal to output light level that allows smooth adjustment over the entire dimming range regardless of the controller type.

J. Flicker: Driver and luminaire electronics shall deliver illumination that is free from objectionable flicker as measured by flicker index (ANSI/IES RP-16-10). At all points within the dimming range from 100-0.1 percent luminaire shall have: Less than 1 percent flicker index at frequencies below 120 Hz and less than 12 percent flicker index at 120 Hz, and shall not increase at greater than 0.1 percent per Hz to a maximum of 80 percent flicker index at 800Hz.

K. Driver disconnect shall be provided where required to comply with codes.

LED ELECTRICAL

A. THD: Total harmonic distortion (current and voltage) induced into an AC power line by a luminaire shall not exceed 20 percent at any standard input voltage and meet ANSI C82.11 maximum allowable THD requirements.

B. Surge Suppression: The luminaire shall include surge protection to withstand high repetition noise and other interference. Withstand up to a 1,000 volt surge without impairment of performance as defined by ANSI C62.41 Category A. To reduce false circuit breaker tripping due to turn on inrush, the following statement ensures that electronic dimming driver will meet NEMA inrush recommendations.

C. Rush Current: Meet or exceed NEMA 410 driver inrush standard of 430 Amps per 10 Amps load with a maximum of 370 Amps2 – seconds.

D. RF Interference: The luminaire and associated onboard circuitry must meet Class A emission limits referred in Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 Non-Consumer requirements for EMI/RFI emissions.

E. Driver must support automatic adaptation, allowing for future luminaire upgrades and enhancements and deliver improved performance.

F. Power Factor: The luminaire shall have a power factor of 90% or greater at all standard operating voltages and full luminaire output.

4. LIGHT FIXTURE GENERAL REQUIREMENTS

A. LED Recessed Lighting Fixtures - General Requirements
(1) The following are minimum requirements for recessed LED fixtures for lay-in grid, gypsum board, plaster and concealed spline ceilings. Surface-mounted LED fixture requirements shall be similar.

(2) Housings shall be a minimum of 4" depth, premium grade, constructed of a minimum 22 gauge die embossed or stiffened cold rolled pre-treated rust-resistant steel. Troffers shall be equivalent to Hubbell "Versaline," Daybrite "Designer," Lightolier equivalent or Lithonia "2SPG" series.

(3) All parts shall be finished with polyester powder or white baked enamel (85% minimum reflectance) painted after fabrication. All wiring shall be type TFN, or THWN and shall be covered by the steel driver cover or wiring channel. Exposed wiring is not acceptable. Connection wiring shall be accessible thru a hinged access plate above driver channel in top of unit.

(4) The complete light fixture unit shall be UL listed and labeled. Other agency listings may be acceptable with written approval from the Engineer.

(5) Fixture lens doors shall be reversible, hinged, painted after fabrication, with spring-loaded or other mechanically stable positive action latches.

(6) Lens shall be as specified for each fixture type. If a specific manufacturer and series number of lens is listed, the substitute shall be of the exact specification (thickness, prism configurations, transparency, efficiency, photometric distribution, hardness, vandal-resistance, etc.). Minimum average thickness of any prismatic lens shall be .125".

(7) Fixture trim and/or flanges shall conform with ceiling constructions as required. Verify all types prior to submission of shop drawings and indicate any special types on submittals. Fixtures installed in drywall or plaster ceilings to be provided with flange, screed and swing gate anchoring system.

(8) All fixtures shall be furnished with hold down clips to meet applicable seismic codes, four clips per fixture minimum or the equivalent thereof in the installation trim. Verify thickness of drywall or plaster ceilings prior to submission of shop drawings, to allow for proper trim adjustment.

(9) Support fixtures with one hanger wire at each end. Hanger wires shall be installed within 15° of plumb, maximum or additional support shall be provided. Wires shall be attached to the fixture body and to the building structure - not to the supports of other work or equipment.

(10) Each type of lay-in fixture shall be furnished with the proper housing flange or lip to suit the type of lay-in grid(s) being utilized on the project. The Contractor is to verify if narrow or standard grid members are being furnished and provide the proper type of light fixture trim. Indicate any special trims on shop drawing submittals.
B. Industrial and Striplight LED Fixtures - General Requirements

(1) Units shall have die-formed heavy gauge cold rolled steel channels and die-embossed reflectors.

(2) Finishes to be coated with a gloss powder paint or baked enamel finish with a minimum 85% reflectance.

(3) Units to have aligner clips where required for a continuous row appearance. Where continuous rows exceed twelve feet in length, provide a "unistrut" channel or similarly adequate mounting to stiffen and align row.

(4) Units to have captive latches for all covers and wire guards where specified. Wire guards shall be heavy-duty #14 wire gauge minimum with corrosion-resistant plated or vinyl finish.

(5) Units to be UL listed.

(6) Mounting brackets and hanging mechanisms shall be as specified in fixture descriptions, or as required. Allow a generous safety margin with all support systems, as recommended by the manufacturer.

C. Recessed Ellipsoidal or Parabolic Cone Downlight - General Requirements

(1) Fixture to have an extruded or die-cast aluminum housing. Retaining mechanism shall provide easy access to LED array and driver box.

(2) Unit to have a corrosion-resistant steel junction box with hinged access covers and thermal protector.

(3) Mounting/plaster frame to be heavy gauge steel with finishing trim friction support springs, for the required ceiling thickness. Trim to be of color as selected by the Architect.

(4) Optical system to consist of a specular clear Alzak upper ellipsoidal (or parabolic, as noted) reflector with specular Alzak cone or microgroove matte black baffle as noted in schedule. Where other than clear Alzak cone/reflector color is noted on the schedule, it shall be furnished as specified.

(5) Provide telescoping channel bar hangers that adjust vertically and horizontally.

(6) Fixtures to be UL listed for thru-branch circuit wiring, recessed, and damp locations. Where installed in plaster or drywall or other inaccessible ceiling type, they shall be U.L. listed for bottom access.

D. Exit Lights - General Requirements
(1) Housings and canopies shall be die-cast aluminum or corrosion resistant steel. Mountings shall be wall or ceiling, universal type, to suit the installation conditions.

(2) Provide with stencil face, lettering color red, of sizes in accord with code, or as otherwise specified.

(3) Provide single or double face as scheduled, indicated on plans or as required by the local authority having jurisdiction. Adjust installation position if required for clear visibility, in accord with applicable codes.

(4) Complete unit to be finished in color as selected by the Architect. Provide directional arrows as indicated on plans, as scheduled to suit the means of egress or as required by the local authority having jurisdiction.

(5) All exit signs shall be long life LED type.

(6) Where emergency backup battery packs are provided with exit lights, they shall have capacities for continuous operation per applicable codes. They shall have reserve battery capacity to operate remote lamps where indicated.

5. LIGHTING FIXTURE SCHEDULE
   A. Refer to the contract drawings for Lighting Fixture Schedule

6. PHOTOCELLS
   A. Provide 120, 277 or 480 volt (rated as needed), 1000 or 2000 watt photocells as needed for control of certain circuits or fixtures as indicated on plans. They shall be as manufactured by Tork, Paragon, AMF or approved equivalent.

   B. Mount photocells in locations concealed from sight lines standing on ground unless otherwise noted, in which case the final position shall be as directed by the Architect. Group together (if indicated at one location) and mount on back of parapet wall or otherwise properly support with mounting bracket. Coordinate with roofing installer to ensure that roof penetrations are properly made without violating or reducing the roof warranty in any way. Photocells may be mounted in other locations if it is not practical to install them on roofs or parapets, in which case the Contractor shall request direction for their mounting locations from the Engineer or Architect. Photocells shall always be mounted in a weatherproof, inconspicuous manner.

7. TIMECLOCKs
   A. Provide digital astronomic timeclock(s) to control the indicated loads. The number of poles, their ampacity and voltage withstand shall be to suit the load, but in no case less than 30 amps, 277 volts.
B. Timeclock coil and motor power shall be 120 volts AC, backed up with seven day memory which is automatically replenished in normal operation. Provide a 120 volt control circuit from the nearest available panelboard.

C. Order unit for the proper geographical latitude for the project site. Also provide day light savings time option and calibrate for April-October dates. Provide instruction to the Owner's representative in proper setting and operation of each type of timeclock provided.

D. Enclosures for timeclocks shall be surface type, NEMA 1 or NEMA 3R as needed. Where exposed in finished areas, provide flush-style NEMA 1 enclosures.

END OF SECTION.
SECTI0N 16510 – NETWORK LIGHTING SYSTEMS

1. 1. BUILDING LIGHTING CONTROL SYSTEM

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. The lighting control system specified in this section shall provide time-based, sensor-based (occupancy), and manual lighting control.

B. The system shall be capable of turning lighting loads on/off as well as dimming lights (if lighting load is capable of being dimmed)

C. The system architecture shall provide stand-alone groups (rooms) of devices to function in a default capacity even if network connectivity to the greater system is lost. The network shall allow for remote troubleshooting and reporting as well as some higher level functionality.

D. The system shall not require any centrally hardwired switching equipment.

E. The system shall be capable of wireless, wired, or hybrid wireless/wired architectures.

F. Graphical floor plan software shall be provided allowing the owner to see devices in specific rooms and by clicking on the symbol with a mouse shall be able to see status, make device adjustments, modify schedules, over-ride, and/or disable devices. The software shall also provide a reporting tool that indicates what savings have been accomplished by use of each technology used in a space over a specified time (Occupancy sensing, daylight harvesting, time of day, etc.)

1.3 SUBMITTALS

A. Product Data: For each type of product.

   A. Specification Conformance Document: Indicate whether the submitted equipment:
      1. Meets specification exactly as stated.
      2. Meets specification via an alternate means and indicate the specific methodology used.

   B. Shop Drawings; include:
1. Schematic (one-line diagram) of system.
2. Mounting dimension requirements for each product and mounting condition.

C. Product Data: Catalog cut sheets with performance specifications demonstrating compliance with specified requirements.

D. Sequence of Operation to describe how each area operates and how any building wide functionality is described.

E. Sequence of Operation to describe how each area operates and how any building wide functionality is described.

F. Provide coordination drawings showing interconnecting control wiring and interface devices.

G. Quality Control Submittals:
   A. Test Reports: Indicating compliance with specified fabric properties.
   B. Certification: Morton International Laboratory Report for PVC coated fabrics and bacterial and mildew resistance.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Operation and Maintenance Data: For lighting controls to include in emergency, operation, and maintenance manuals.

B. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Program Software Backup: On magnetic media or compact disk, complete with data files.
   3. Device address list.
   4. Printout of software application and graphic screens.

1.5 QUALITY ASSURANCE

A. Retain "Testing Agency Qualifications" Paragraph below if Contractor selects testing agency or if Contractor is required to provide services of a qualified testing agency in "Field Quality Control" Article. Qualification requirements are in addition to those specified in Section 01 40 00 "Quality Requirements," which also defines "NRTL" (nationally recognized testing laboratory).

B. All steps in sensor manufacturing process shall occur in the USA; including population of all electronic components on circuit boards, soldering, programming, wiring, and housing.

C. All components and the manufacturing facility where product was manufactured must be ROHS compliant.

D. In high humidity or cold environments, the sensors shall be conformably coated and rated
for condensing humidity and -40 degree Fahrenheit (and Celsius) operation.

E. All applicable products must be UL/CUL Listed or other acceptable national testing organization.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Handle and prepare panels for installation according to NECA 407.

1.7 COORDINATION

A. Coordinate lighting control components to form an integrated interconnection of compatible components.

B. Coordinate lighting controls with BAS (if necessary) either through IP based intercommunication of system or hardwired auxiliary relay outputs.

C. The installing contractor shall be responsible for a complete and functional system in accordance with all applicable local and national codes.

1.8 WARRANTY

A. All devices in lighting control system shall have a 5 year warranty. Warranty shall start at Final Project Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. This specification is based on the nLight Network Control System from Sensor Switch, by Watt Stopper or Cooper Controls.

2.2 SYSTEM REQUIREMENTS

A. The system shall be a networked lighting system.

B. Intelligent lighting control devices shall consist of one or more basic lighting control components; occupancy sensors, photocell sensors, relays, dimming outputs, manual switch stations, and manual dimming stations. Combining one or more of these components into a single device enclosure should be permissible so as to minimize overall device count of system.

C. System must interface directly with intelligent LED luminaires such that only CAT-5 cabling is required to interconnect luminaires with control components such as sensors and switches (see Networked LED Luminaire section)

D. Intelligent lighting control devices shall communicate digitally, require <4 mA of current to function (Graphic wall stations excluded), and posses RJ-45 style connectors.
E. Lighting control zones shall consist of one or more intelligent lighting control components, be capable of stand-alone operation, and be capable of being connected to a higher level network backbone.

F. Devices within a lighting control zone shall be connected with CAT-5E low voltage cabling in any order.

G. Lighting control zone shall be capable of automatically configuring itself for default operation without any start-up labor required.

H. Individual lighting zones must continue to provide a user defined default level of lighting control in the event of a system communication failure with the backbone network or the management software becoming unavailable.

I. Power for devices within a lighting control zone shall come from either resident devices already present for switching (relay device) or dimming purposes, or from the network backbone. Standalone “bus power supplies” shall not be required in all cases.

J. All switching and dimming for a specific lighting zone shall take place within the devices located in the zone itself (i.e. not in a remotely located devices such as panels) to facilitate system robustness and minimize wiring requirements. Specific applications that require centralized or remote switching shall be capable of being accommodated.

K. System shall have one or more primary wall mounted network control “gateway” devices that are capable of accessing and controlling connected system devices and linking into an Ethernet LAN.

L. System shall use “bridge” devices that route communication and distribute power for up to 8 directly connected lighting zones together for purposes of decreasing system wiring requirements.

M. System shall be capable of wirelessly connecting a lighting zone to a WiFi (802.11n) wireless data network for purposes of eliminating the “bridge” devices and all cabling that connects zones to bridge devices.

N. WiFi enabled devices shall be able to detect when WiFi network is down and revert to a user directed default state.

O. WiFi-enabled devices shall be capable of current monitoring

P. WiFi-enabled devices shall utilize WPA2 AES encryption

Q. WiFi-enabled devices shall be able to connect to 802.11b/g/n WiFi networks

R. WiFi-enabled devices shall have at least one local RJ-45 port for communicating with nonWiFi- enabled system devices

S. System shall have a web-based software management program that enables remote system control, status monitoring, and creation of lighting control profiles.
T. Individual lighting zones shall be capable of being segmented into several “local” channels of occupancy, photocell, and switch functionality for more advanced configurations and sequences of operation.

U. Devices located in different lighting zones shall be able to communicate occupancy, photocell, and switch information via either the wired or WiFi backbone.

V. System shall be capable of operating a lighting control zone according to several sequences of operation. System shall be able to change a spaces sequence of operation according to a time schedule so as to enable customized time-of-day, day-of-week utilization of a space. Note operating modes should be utilized only in manners consistent with local energy codes.

W. A taskbar style desktop application shall be available for personal lighting control.

X. An application that runs on “smart” handheld devices (such as an Apple® IPhone®) shall be available for personal lighting control.

Y. Control software shall enable logging of system performance data and presenting useful information in a web-based graphical format and downloadable to .CSV files.

Z. Control software shall enable integration with a BMS via BACnet IP.

AA. System shall provide the option of having pre-terminated plenum rated CAT-5 cabling supplied with hardware.

2.3 INDIVIDUAL DEVICE SPECIFICATIONS

A. Control Module (Gateway)

1. Control module shall be a device that facilitates communication and time-based control of downstream network devices and linking into an Ethernet.

2. Devices shall have a user interface that is capable of wall mounting, powered by low voltage, and have a touch screen.

3. Control device shall have three RJ-45 ports for connection to other backbone devices (bridges) or directly to lighting control devices.

4. Device shall automatically detect all devices downstream of it.

5. Device shall have a standard and astronomical internal time clock.

6. Device shall have one RJ-45 10/100 BaseT Ethernet connection.

7. Device shall have a USB port

8. Each control gateway device shall be capable of linking 1500 devices to the
management software.

9. Device shall be capable of using a dedicated or DHCP assigned IP address.

B. Networked System Occupancy Sensors

1. Occupancy sensors system shall sense the presence of human activity within the desired space and fully control the on/off function of the lights.

2. Sensors shall utilize passive infrared (PIR) technology, which detects occupant motion, to initially turn lights on from an off state; thus preventing false on conditions. Ultrasonic or Microwave based sensing technologies shall not be accepted.

3. For applications where a second method of sensing is necessary to adequately detect maintained occupancy (such as in rooms with obstructions), a sensor with an additional “dual” technology shall be used.

4. Dual technology sensors shall have one of its two technologies not require motion to detect occupancy. Acceptable dual technology includes PIR/Microphonics (also known as Passive Dual Technology or PDT) which both looks for occupant motion and listens for sounds indicating occupants. Sensors where both technologies detect motion (PIR/Ultrasonic) shall not be acceptable.

5. All sensing technologies shall be acoustically passive meaning they do not transmit sounds waves of any frequency (for example in the Ultrasonic range), as these technologies have the potential for interference with other electronic devices within the space (such as electronic white board readers). Acceptable detection technologies include Passive Infrared (PIR), and/or Microphonics technology. Ultrasonic or Microwave based sensing technologies shall not be accepted.

6. Sensors shall be available with zero, one, or two integrated Class 1 switching relays, and up to one 0-10 VDC dimming output. Sensors shall be capable of switching 120 / 277 / 347 VAC. Load ratings shall be 800 W @ 120 VAC, 1200 W @ 277 VAC, 1500 W @ 347 VAC, and ¼ HP motor. Relays shall be dry contacts.

7. Sensors shall be available with one or two occupancy “poles”, each of which provides a programmable time delay.

8. Sensors shall be available in multiple lens options which are customized for specific applications.

9. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.

10. All sensors shall have two RJ-45 ports or capable of utilizing a splitter.
11. All sensors shall have the ability to detect when it is not receiving valid communication (via CAT-5 connections) and blink its LED in a pattern to visually indicate of a potential wiring issue.

12. Every sensor parameter shall be available and configurable remotely from the software and locally via the device push-button.

13. Sensors shall be able to function together with other sensors in order to provide expanded coverage areas by simply daisy-chain wiring together the units with CAT-5 cabling.

14. Sensors shall be equipped with an automatic override for 100 hour burn-in of lamps. This feature must be available at any time for lamp replacements.

15. Wall switch sensors shall recess into single-gang switch box and fit a standard GFI opening.

16. Wall switch sensors must meet NEC grounding requirements by providing a dedicated ground connection and grounding to mounting strap. Line and load wire connections shall be interchangeable. Sensor shall not allow current to pass to the load when sensor is in the unoccupied (Off) condition.

17. Wall switch sensors shall have optional features for photocell/daylight override, vandal resistant lens, and low temperature/high humidity operation.

18. Wall switch sensors shall be available in four standard colors (Ivory, White, Light Almond, Gray). Wall plates shall be brushed stainless steel.

19. Wall switch sensors shall be available with optional raise/lower dimming adjustment controls.

20. Network system shall have sensors that can be embedded into luminaire such that only the lens shows on luminaire face.

21. Embedded sensors shall be capable of both PIR and Dual Technology occupancy detection.

22. Embedded sensors shall have an optional photocell.

23. Network system shall also have ceiling, fixture, recessed, & corner mounted sensors available.

24. Fixture mount sensors shall be capable of powering themselves via a line power feed.

25. Sensors shall have optional features for photocell/daylight override, dimming control, and low temperature/high humidity operation.

26. Sensors with dimming can control 0 to 10 VDC dimmable ballasts by sinking up to 20 mA of Class 2 current (typically 40 or more ballasts).
27. System shall have WiFi enabled fixture mountable sensors available.

28. Embedded sensors shall have an optional photocell and 0-10 VDC dimming output

C. Networked System Daylight (Photocell and or Dimming) Sensors

1. Photocell shall provide for an on/off set-point, and a deadband to prevent the artificial light from cycling. Delay shall be incorporated into the photocell to prevent rapid response to passing clouds.

2. Photocell and dimming sensor’s set-point and deadband shall be automatically calibrated through the sensor’s microprocessor by initiating an “Automatic Set-point Programming” procedure. Min and max dim settings as well as set-point may be manually entered.

3. Deadband setting shall be verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space (i.e., furniture layouts, lamp depreciation, or lamp outages).

4. Dimming sensors shall control 0 to 10 VDC dimmable ballasts by sinking up to 20 mA of class 2 current (typically 40 or more ballasts).

5. Photocell and dimming sensors shall be equipped with an automatic override for 100 hour burn-in of lamps. This feature must be available at any time for lamp replacements. (Note: This function should be performed prior to any dimming of the lamps including the “auto set-point” setting.)

6. Combination units that have all features of on/off photocell and dimming sensors shall also be available.

7. A dual zone option shall be available for On/Off Photocell, Automatic Dimming Control Photocell, or Combination units. The second zone shall be capable of being controlled as an “offset” from the primary zone.

8. Line voltage versions of the above described photocell and combination photocell/dimming sensors shall be capable of switching both 120 VAC, 277 VAC, and 347 VAC. Load ratings shall be 800 W @ 120 VAC, 1200 W @ 277 VAC, 1500 W @ 347 VAC, and ¼ HP motor load. Relays shall be dry contacts.

9. Network system shall have dimming photocells that can be embedded into luminaire such that only the lens shows on luminaire face.

D. Networked System Metering Power (Relay) Packs

1. Power Pack shall incorporate one or more Class 1 relays and contribute low voltage power to the rest of the system. Secondary Packs shall incorporate the relay(s), shall have an optional 2nd relay, 0-10 VDC dimming output, or line voltage dimming.
output, but shall not be required to contribute system power. Power Supplies shall provide system power only, but are not required to switch line voltage circuit. Auxiliary Relay Packs shall switch low voltage circuits only.

2. Power Packs shall accept 120 or 277 VAC (or optionally 347 VAC), be plenum rated, and provide Class 2 power to the system and come capable of metering connected load.

3. All devices shall have two RJ-45 ports.

4. Every Power Pack parameter shall be available and configurable remotely from the software and locally via the device push-button.

5. Power Pack shall securely mount to junction location through a threaded ½ inch chase nipple or be capable of being secured within a luminaire ballast channel. Plastic clips into junction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads. Note: UL Listing under Energy Management or Industrial Control Equipment automatically meets this requirement, whereas Appliance Control Listing does not meet this safety requirement.

6. When required by local code, Power Pack must install inside standard electrical enclosure and provide UL recognized support to junction box. All Class 1 wiring is to pass through chase nipple into adjacent junction box without any exposure of wire leads.

7. Power Packs and Power Supplies shall be available that are WiFi enabled.

8. Power (Secondary) Packs shall be available that provide up to 16 Amp switching of all lighting load types.

9. Power (Secondary) Packs shall be available that provide up to 5 Amps switching of all lighting load types as well as 0-10 VDC dimming or fluorescent ballasts/LED drivers.

10. Specific Secondary Packs shall be available that provide up to 5 Amps of switching as well as 0-10 VDC dimming of fluorescent ballasts/LED drivers.

11. Specific Secondary Packs shall be available that provide up to 5 Amps of switching and can dim 120 VAC incandescent lighting loads or 120/277 VAC line voltage dimmable fluorescent ballasts (2-wire and 3-wire versions).

12. Specific Secondary Packs shall be available that provide up to 5 Amps of switching and can dim 120/277 VAC magnetic low voltage transformers.

13. Specific Secondary Packs shall be available that provide up to 4 Amps of switching and can dim 120 VAC electronic low voltage transformers.

14. Specific Secondary Packs shall be available that provide up to 5 Amps of switching of dual phase (208/240/480 VAC) lighting loads.
15. Specific Secondary Packs shall be available that require a manual switch signal (via a networked Wall Station) in order to close its relay.

16. Specific Power/Secondary Packs shall be available that are UL924 listed for switching of Emergency Power circuits.

17. Specific Secondary Packs shall be available that control louver/damper motors for skylights.

18. Specific Secondary Packs shall be available that provide a pulse on/pulse off signal for purposes of controlling shade systems via relay inputs.

E. Networked System Relay & Dimming Panels

1. Panel shall incorporate up to 4 normally closed latching relays capable of switching 120/277 VAC or up to 2 Dual Phase relays capable of switching 208/240/480 VAC loads.

2. Relays shall be rated to switch up to a 30A ballast load at 277 VAC.

3. Panel shall provide one 0-10VDC dimming output paired with each relay.

4. Panel shall power itself from an integrated 120/277 VAC supply.

5. Panel shall be capable of operating as either two networked devices or as one.

6. Panel shall supply current limited low voltage power to other networked devices connected via CAT-5.

7. Panel shall provide auxiliary low voltage device power connected wired directly to a dedicated terminal connection

F. Networked Auxiliary Input / Output (I/O) Devices

1. Devices shall be plenum rated and be inline wired, screw mountable, or have an extended chase nipple for mounting to a ½” knockout.

2. Devices shall have two RJ-45 ports

3. Communication and low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.

4. Specific I/O devices shall have a dimming control output that can control 0-10 VDC dimmable ballasts or LED drivers by sinking up to 20 mA of current (typically 40 or more ballasts).

5. Specific I/O devices shall have an input that read a 0-10 VDC signal from an external device.
6. Specific I/O devices shall have a switch input that can interface with either a maintained or momentary switch and run a switch event, run a local/remote control profile, or raise/lower a dimming output.

7. Specific I/O devices shall sense state of low voltage outdoor photocells.

8. Specific I/O devices shall enable RS-232 communication between lighting control system and Touch Screen based A/V control systems.

9. Specific I/O devices shall sense .

G. Networked LED Luminares

1. Networked LED luminaire shall have a mechanically integrated control device.

2. Networked LED luminaire shall have two RJ-45 ports.

3. Networked LED luminaire shall be able to digitally network directly to other network control devices (sensors, photocells, switches, dimmers).

4. Networked LED luminaire shall provide low voltage power to other networked control devices.

5. System shall be able to turn on/off LED luminaire without using a relay.

6. System shall be able to maintain constant lumen output over the specified life of the LED luminaire (also called lumen compensation) by varying the input control power (and thus saving up to 20% power usage).

7. System shall indicate (via a blink warning) when the LED luminaire has reached its expected life (in hrs).

H. Networked System Wall Switches & Dimmers

1. Devices shall recess into single-gang switch box and fit a standard GFI opening.

2. Devices shall be available with zero or one integrated Class 1 switching relay.

3. Communication and low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.

4. All sensors shall have two RJ-45 ports.

5. All devices shall provide toggle switch control. Dimming control and low temperature/high humidity operation are available options.

6. Devices shall be available in four colors (Ivory, White, Light Almond, Gray).

7. Devices with dimming control outputs can control 0-10 VDC dimmable ballasts.
by sinking up to 20 mA of current (typically 40 or more ballasts).

8. Devices with capacitive touch buttons shall provide audible user feedback with different sounds for on/off, raise/lower, start-up, and communication offline.

9. Devices with mechanical push-buttons shall provide tactile and LED user feedback.

10. Devices with mechanical push-buttons shall be made available with custom button labeling.

11. Devices with a single on button shall be capable of selecting all possible lighting combinations for a bi-level lighting zone such that the user confusion as to which of two buttons (as is present in multi-button scenarios) controls which load is eliminated.

I. Networked System Graphic Wall Station (Acuity Fresco or equivalent by Wattstopper, Crestron, Hubbell).

1. Device shall have a 3.5” full color touch screen for selecting up to 8 programmable lighting control presets or acting as up to 16 on/off/dim control switches.

2. Device shall enable configuration of lighting presets, switched, and dimmers via password protected setup screens.

3. Device shall enable user supplied .jpg screen saver image to be uploaded.

4. Device shall surface mount to single-gang switch box.

5. Device shall have a micro-USB style connector for local computer connectivity.

6. Device shall have two RJ-45 ports for communication.

J. Networked System Scene Controllers

1. Device shall have two to four buttons for selecting programmable lighting control profiles or acting as on/off switches.

2. Device shall recess into single-gang switch box and fit a standard GFI opening.

3. Devices shall provide LED user feedback.

4. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.

5. All sensors shall have two RJ-45 ports.

6. Device shall be capable of reprogramming other devices in its zone so as to implement user selected lighting scene.
7. Device shall be capable of selecting a lighting profile be run by the system’s upstream Gateway so as to implement selected lighting profile across multiple zones (and not just its local zone).

8. Device shall have LEDs indicating current selection.

K. Communication Bridges

1. Device shall surface mount to a standard 4” x 4” square junction box.

2. Device shall have 8 RJ-45 ports.

3. Device shall be capable of aggregating communication from multiple lighting control zones for purposes of minimizing backbone wiring requirements back to Control Gateway.

4. Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply or delivered via a CAT-5 cabled connection.

5. Device shall be careful of redistributing power from its local supply and connect lighting control zones with excess power to lighting control zones with insufficient local power. This architecture also enables loss of power to a particular area to be less impactful on network lighting control system.

2.4 LIGHTING CONTROL PROFILES

A. Changes to the operation of the system shall be capable of being made in real-time or scheduled via lighting control profiles. These profiles are outlines of settings that direct how a collection of devices function for a defined time period.

B. Lighting control profiles shall be capable of being created and applied to a single device, zone of devices, or customized group of zones.

C. All relays and dimming outputs shall be capable of being scheduled to track or ignore information regarding occupancy, daylight, and local user switches via lighting control profiles.

D. Every device parameter (e.g. sensor time delay and photocell set-point) shall be configurable via a lighting control profile.

E. All lighting control profiles shall be stored on the network control gateway device and on the software’s host server.

F. Lighting control profiles shall be capable of being scheduled to run according to the following calendar options: start date/hour/minute, end date/hour/minute, and sunrise/sunset +/- timed offsets.

G. Sunrise/sunset times shall be automatically derived from location information using an astronomical clock.
H. Daylight savings time adjustments shall be capable of being performed automatically, if desired.

I. Lighting control profile schedules shall be capable of being given the following recurrence settings: daily, weekday, weekend, weekly, monthly, and yearly.

J. Software shall provide a graphical tool for easily viewing scheduled lighting control profiles.

2.5 START-UP & SUPPORT FEATURES

A. To facilitate start-up, all devices daisy-chained together (using CAT-5) shall automatically be grouped together into a functional lighting control zone.

B. All lighting control zones shall be able to function according to default settings once adequate power is applied and before any system software is installed.

C. Once software is installed, system shall be able to auto-discover all system devices without requiring any commissioning.

D. All system devices shall be capable of being given user defined names.

E. All devices within the network shall be able to have their firmware reprogrammed remotely and without being physically uninstalled for purposes of upgrading functionality at a later date.

F. All sensor devices shall have the ability to detect improper communication wiring and blink its LED in a specific cadence as to alert installation/startup personnel.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panels according to NECA 407.

B. Examine panels before installation. Reject panels that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panels for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
H. Install equipment in accordance with manufacturer’s installation instructions.

I. Provide complete installation of system in accordance with Contract Documents.

J. Provide equipment at locations and in quantities indicated on Drawings. Provide any additional equipment required to provide control intent.

K. Define each dimmer's/relay’s load type, assign each load to a zone, and set control functions.

L. Season lamps at full intensity according to lamp manufacturer’s recommendation.

M. Install equipment in accordance with manufacturer's installation instructions.

N. Provide complete installation of system in accordance with Contract Documents.

O. Provide equipment at locations and in quantities indicated on Drawings. Provide any additional equipment required to provide control intent.

P. Define each dimmer's/relay’s load type, assign each load to a zone, and set control functions.

Q. Season lamps at full intensity according to lamp manufacturer’s recommendation.

R. Install plenum cable in environmental air spaces, including plenum ceilings.

S. Comply with requirements for raceways and boxes specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

T. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

U. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals.

B. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

C. Create a directory to indicate loads served by each relay; incorporate Owner's final room designations. Obtain approval before installing. Use a PC or typewriter to create directory; handwritten directories are unacceptable.

D. Lighting Control Panel Nameplates: Label each panel with a nameplate.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Acceptance Testing Preparation:

1. Test continuity of each circuit.

D. Lighting control panel will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies lighting control panels and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Confirm correct communications wiring, initiate communications between panels, and program the lighting control system according to approved configuration schedules, time-of-day schedules, and input override assignments.

B. Required factory-trained personnel site visits:

1. Pre-installation: The system shall be provided with visits from factory trained technician(s) for a pre-installation visit with the contractor prior to system installation.
2. Commissioning and Programming: A second visit shall be included for commissioning and programming of the system including testing of switches and sensors.
3. Owner Training: A third visit shall be provided for owner training after the owner has occupied the building. Minimum four hour training to be video recorded.
4. Owner Re-Training and System Adjustment: A fourth visit 6 months after the owner has occupied the building shall be provided to tweak the system for occupant preferences and for additional training.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for
3.7 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.8 SEQUENCE OF OPERATION

A. Classrooms Without Daylighting:

1. Low voltage dimmer switches shall be located at the entrance to the space. Each switch shall control a single zone of lighting and provide on/off and raise/lower control of that zone. A vacancy sensor with time delay set to 30 minutes shall be located near the center of the room for maximum occupant detection. Lighting shall be zones as follows: The row of lights along the projector wall shall be a zone. The remainder of the lights in the room shall be a zone. See typical classroom layout.

B. Offices Without Daylighting:

1. A low voltage dimmer switches with integral vacancy sensor shall be located at the entrance to each space. The switch shall control a single zone of lighting and provide on/off and raise/lower control of that zone. The vacancy sensor time delay shall be set to 10 minutes.

C. Corridor/Lobbies/Vestibules:

1. Occupancy sensors with time delays set to 30 minutes shall be located as shown on the drawings (and field adjusted for best occupant detection).

D. Restrooms:

1. The restrooms shall be controlled via occupancy sensors. The system shall be programmed to remain on during normal school hours for security. After hours the occupancy sensor shall control the lighting. Switches in restrooms will be used for over-ride to on only. In single gang restrooms occupancy sensor switches located at the entrance to the space shall be provided. In multigang restrooms, a low voltage switch located at the entrance to the space shall be provided and a minimum of two (more as required) ceiling mount occupancy sensors shall be provided.

E. Storage Rooms:
1. A low voltage switch shall be located at the entrance to the space. A minimum of one vacancy sensor with time delay set to 5 minutes shall be provided. The sensor shall be ceiling mount or integral to the switch (as indicated on the drawings).

F. Media Center:

1. A low voltage switch shall be located at each entrance to the space. Each of these switches shall provide on/off control of all zones of lighting simultaneously. A master station with graphical touch screen interface shall be provided at the circulation desk to provide on/off and raise/lower control of each individual zone of lighting. The master station shall also provide scenes of lighting selectable by preset through the interface. An astronomical timeclock integral to the master station will turn on lighting zone ‘b’ at [OP] AM Monday through Friday and shut off all lighting zones at [OP] PM Sunday through Saturday.

G. Electrical / Mechanical / Data Rooms:

1. A low voltage switch shall be located at the entrance to the space. For occupant safety, no automatic lighting control shall be provided.

H. Exterior Lighting:

1. A relay panel with integral digital timeclock + photocell shall control all new and existing exterior lighting. The relay panel shall be located per the drawings. The photocell shall be located on the roof of the new addition, per manufacturers requirements. The photocell shall turn on all exterior lighting at [OP] PM. The digital timeclock shall turn off all exterior lighting at [OP] AM/PM.

I. Notes on Sequence of Operation:

1. [OP] indicates a schedule/time that is to be per the owner's preference. The lighting controls contractor shall coordinate the occupied/unoccupied times with the owner during system programming and startup.

3.9 SERVICE AND SUPPORT

1. Provide factory certified field service engineer to make minimum of three site visits to ensure proper system installation and operation under following parameters
   a. Qualifications for factory certified field service engineer:
      1) Minimum experience of 2 years training in the electrical/electronic field.
      2) Certified by the equipment manufacturer on the system installed.
   b. Make first visit prior to installation of wiring. Contractor must schedule meeting Electrical Engineer and Manufacturer representative to review system and functionality prior to installation of wire and equipment.
   c. Make second visit upon completion of installation of Network Lighting Control System for system start up. Schedule start up with owner and engineer with 2
weeks prior notice.

d. A total two (2) Owner training session with the electrical contractor, the lighting controls contractor, the factory authorized representative, engineer of record, and the owner (and staff) shall be conducted at the project site. The training session shall be scheduled a minimum of 2 weeks prior. The training session shall not be conducted until the lighting controls system has been programmed and is fully operational.

e. A total of two (2) walk thrus shall be conducted after completion of construction to assure that the system is fully operational. The walk thrus shall be schedule a minimum of 2 weeks prior and shall be conducted at the request of the owner or engineer of record. In lieu of a formal request from the owner or engineer of record the walk thrus shall be conducted 3 months and 9 months after completion of construction. Reports shall be issued at each walk-thru.

END OF SECTION.
SECTION 16720 - PAGING/INTERCOM SYSTEM

1. GENERAL REQUIREMENTS

A. Scope of the Work

(1) The work to be provided herein consists of furnishing and installing all equipment, cabling and labor required for a complete, operable, new administrative communication and control system for the school.

(2) The equipment specified herein is based on equipment manufactured by DUKANE CORPORATION and distributed by General Sound & Electronics. Rauland and Simplex are acceptable manufacturers.

(3) The electronic systems contractor shall be the manufacturer's authorized representative for the equipment proposed and have adequate experience with the proposed manufacturer's equipment and submit proof of having been a factory authorized distributor for the proposed product for at least five years.

(4) The electronic systems contractor shall have a factory trained service department on call 24 hours a day, 365 days a year, to service the specified product.

(5) The electronics systems contractor shall provide a reference list of five similar sized projects installed by the contractor including contacts and telephone numbers.

(6) Intentional or unintentional painting of exposed low voltage or line voltage cabling is prohibited. The contractor shall ensure that exposed cabling is adequately protected from direct painting or overspray whether painting is required within the electrical specifications or required by other disciplines/trades. The contractor shall review the painting requirements for all disciplines and shall provide cabling protection as required. Where exposed cabling is being installed in exposed ceiling or wall spaces that are required to be painted, the contractor shall provide alternate options for cable colors and shall provide submittals for such cabling to engineer for approval.

2. VOICE COMMUNICATIONS AND SOUND SYSTEM.

A. General

(1) Furnish and install a complete microprocessor controlled voice communication system with all wire, outlets and equipment as may be required, as shown on the drawings, and as herein specified to provide a complete and operational sound and voice communication system.

(2) The entire system shall be listed by Underwriters Laboratories. Proof of such a listing shall be furnished at time of submittal. All equipment shall be installed and connected in strict
accordance with the manufacturer's recommended instructions. Systems having UL listings on power supplies and amplifiers only shall not be acceptable.

(3) Any proposed substitute system must be shown to meet specifications by the bidder who shall, during the pre-bidding period, attach the manufacturer's name and model numbers of such equipment and material together with three copies of manufacturer's data sheets and submit to the architect/engineer ten working days prior to bid opening for bidding approval. Approval of substitute manufacturer must be issued in writing prior to date of bid.

(4) The electrical contractor shall have appropriate voltage regulation equipment installed on the AC voltage supply taking care to arrest damaging electrical transient and spikes which can cause damage to the microprocessor components of the system.

(5) The vendor shall provide the following documentation and services:

a. Submittals and Shop drawings: twelve (12) sets. These drawings shall include the manufacturer's specification sheets, including all the component parts, control equipment drawings, and layouts, wiring diagrams and facility wiring, and conduit drawings.

b. As built drawings: three (3) sets. These drawings shall include the information in "[1]" above. They should include up-to-date drawings that include any changes made to the system during installation as well as operators manuals and instructions.

c. In-service Training: Provide the owner with a training program designed to make all administrative control center users familiar with the operation of the voice communication system.

B. System Description

(1) The system shall consist of a central equipment cabinet, microprocessor control unit, power supply, zone modules, administrative control centers (ACC’s), amplifiers, remote display units, classroom loudspeaker assemblies, call-in switches, and all associated material, hardware, wiring, and options as described herein to provide a complete working system which shall meet the specified requirements. System up to and including sixty-four (64) stations are to be wall mounted.

(2) The system shall provide the following communication paths and functions:

a. ACC to a single classroom loudspeaker.

b. Administrative control center to administrative control center.

c. Simultaneous program distribution directed from any ACC without interrupting the intercom channel.

The system shall be designed so as to accomplish any combination or all of the above functions simultaneously.
(3) The system shall provide the facilities for:

   a. Paging
   b. Sounding emergency signals
   c. Timed event signals
   d. Control and distribution of one program channel to individual classrooms, selected groups, or all classroom speakers.

(4) The system shall include the facilities for a master clock and programmer. The system master clock will be capable of correcting compatible brands of analog or digital or both types of secondary clocks.

(5) The system shall have an RS232 port for down load/up load capability. Provide owner with a diskette containing their bell schedule, architectural room number information, zone assignments for paging, and bell schedule. Information shall be loaded and unloaded from a standard P.C.

(6) Provide off-site diagnostic capability through RS232 port. Use of programming mode shall not inhibit system operation.

(7) The system will use industry standard 25-volt technology.

C. System Function

(1) The system shall provide a minimum of two intercom channels.

   a. Provide microprocessor-based equipment of modular design, utilizing plug-in connections between all modules.
   b. Facilities to originate emergency calls which take precedence over all routine calls.
   c. System check with self diagnostics.
   d. System to support up to four ACC's each having identical functions and control features.
   e. Automatic gain control on intercom speech channel.
   f. Built-in battery backup for internal system clock to maintain correct time for a period of 7 days after power loss. All other programmed data shall be stored in non-volatile EEPROM memory and will be retained indefinitely.
   g. Automatic pre-announce tone over any loudspeaker selected for two-way communications. A privacy tone will sound whenever a loudspeaker is being monitored.
   h. Distribution of paging announcements via any ACC.
   i. Classroom loudspeakers are user programmable to any of eight paging zones or class change zones.
   j. Unique system tones for emergency and civil emergency.
   k. Special tone for custodial call to all speakers.
   l. Programmable tones such as warble, siren, chime, etc. six separate items available.
   m. Two way intercom communication from each speaker location.
   n. Speaker line supervision of an open circuit condition.
   o. Last number redial.
p. Speed dial access to specific remote stations.
q. Clear all calls registered on the ACC queue.
r. Scroll waiting calls and select calls to be answered in any order.
s. Call waiting indication: Steady display for normal calls; flashing display for emergency calls in order of priority.
t. Call-in reminder in which unanswered calls will repeat until answered.
u. LCD display for current call/calls waiting. Current time is displayed when the ACC is in an idle state.
v. Provide one VOX handset (for private communications), built-in microphone, speaker, and push-to-talk button on each ACC for intercom communications.
w. Review of all incoming calls/calls waiting at each ACC with 100% call retention.
x. The system shall be zoned as follows:
   1) Each classroom shall be considered one zone and shall have a dedicated audio circuit to the central equipment cabinet.
   2) All corridor speakers will be on one zone.
   3) All outside horns will be on one zone.
y. The system shall be programmed to annunciate at any one or all ACC’s.
   1. Self diagnostics for each ACC.
   2. Easy menu-driven programming
   3. Programmable system functions, including:
      1) Architectural alphanumeric room numbers (i.e. B101 etc.)
      2) Five call-in priority levels.
      3) Two, Three, or four digit alphanumeric dialing.
      4) Twelve hour or twenty-four hour clock display when ACC is in the idle state.
      5) Two hundred and fifty-six events, eight time schedules, eight zones, and eight user-programmable tones.
   i. Each classroom shall be programmed to receive the program source on a selected basis.
   2. The system shall not require motor driven fans to keep system components cool.
   3. Outside horns shall be activated for emergency announcements and tones only. Routine announcements and class change tones shall not go out over the outside horns.
   4. Simultaneous program distribution and two intercom channels.
   5. Compatible with Dukane RDU350 remote display units for display of incoming calls and activity within the system.
   6. System is to be compatible with a DTMF phone system and be able to use touch-tone phones to make and receive call from within the system.
   7. System is to have a user-programmable, battery-backed master clock.
   8. System is to be able to drive either digital or analogue clocks or both from within the system.
ss. System capacity shall be up to 256 remote stations and/or call points with up to four administration control units [ACC's], up to 32 remote display units [RDU350] and unlimited interconnection to a phone system.

tt. The system is to have user programmable input ports that allow external devices to trigger time and emergency tones, external all-call, door monitor, night transferswitch, and other system functions. User programmable dry contact outputs are provided to signal external devices when such functions as clock synchronization, all call, and remote annunciations occur.

uu. System is to have an RS-232 Port for P.C. or Dukane SmartSystem interface.

D. System Master Clock

(1) The system shall contain an integral master clock and programmer which shall be capable of performing the following functions:

a. Displaying the time of day in either twelve or twenty-four hour format at each Administrative Control.

b. Providing 256 discrete time event entries for programming functions based on:

1) The time of day in hours and minutes.
2) The day or combination of seven {7} days of the week the event is to occur.
3) Selection of any one or any combination of eight {8} zones or outputs to be activated.
4) Selection of any one of eight schedules to allow for maximum flexibility due to special circumstances or seasonal changes
5) Selection of fourteen user programmable tones.

c. Provide for an editing and review routine to permit the user to change and edit time events, zones, and schedules.

d. Correct compatible brands of secondary clocks, analog or digital or both.

E. Administrative Control Center [ACC]

(1) The administrative control center {ACC} shall be the control center for communications, paging, program distribution and signaling. The ACC will provide the following:

a. Listening level control for intercom channel or program channel.

b. Automatic gain control on intercom microphones.

c. Provide one VOX handset {for private communications}, built-in microphone, speaker, and push-to-talk button on each ACC for intercom communications.

d. ACC self Diagnostics.

e. Provide ACC-keypad, menu-driven programmable systems functions, including:

1) Architectural alphanumeric room numbers with option to program call-in registering only at specific ACC's.
2) Room Call-in priority levels.
3) Twelve or twenty-four hour time clock.
4) Two-hundred-fifty-six event, eight time schedules, eight zones.
5) Eight (8) speaker paging zones.
6) System tone characteristics.
7) Eight (8) Speaker program zone assignment
8) Eight (8) Speaker time tone zone.

f. Provide access code for user-restricted entry to system programming functions.
g. Facility for emergency calls to take precedence over routine calls.
h. Distinct call-in alert tone for emergency call-in.
i. Provide distribution of special tone to all speakers for custodial call.
j. Provide built-in speaker at ACC to monitor program channel.
k. The 31-key color coded spillproof keypad is to include, but not limited to, an EMERGENCY, CUSTODIAN, PAGE, PROGRAM CONSOLE, SYSTEM, HOLD, and 10 speed dial keys.
l. System programming may be accomplished from an ACC4 or from a P.C. type computer with the Dukane MCS350PAL software.
m. The ACC4 shall be capable of 100% queueing of incoming calls in priority sequence.

3. SYSTEM COMPONENTS

A. Central Equipment

(1) The central equipment shall be rack mounted in a standard cabinet. The central cabinet shall contain the following equipment. (The central cabinet to be sized as required to house all equipment. Provide dimensions of housing in shop drawings)

a. Digital card.
b. Analog card.
c. Telapex card one required.
d. Zone switching card as required to accommodate system capacity.
e. Power supply as required
f. System Amplifier(s) [ sized to meet the load of the system ]
g. Battery Back-up/UPS
h. Also include cable T.V. equipment in the paging/intercom rack.

(2) The unit shall require 110 VAC power but in the event of a power failure, the system shall switch over to a standby battery backup system provided by this contractor.

(3) The unit shall be a DUKANE MCS350 (with battery backup). Provide adequate number of zones to meet specifications plus 10% spare.

B. Administrative Control Center (ACC) (Three required)
(1) The administrative control center shall be a desk top unit located in the main office. It shall have a modular jack for quick disconnect for servicing. Provide two units.

(2) The administrative control centers shall be a DUKANE ACC4.

C. AM/FM Tuner/Cassette Player/CD Player

(1) Provide DUKANE Model (RTC-350P) AM/FM tuner cassette. Provide AM/FM antenna with the unit. Mount the antenna outdoors.

(2) Unit shall have a microphone input.

(3) Unit shall be suitable for mounting in wall or in a free standing rack.

(4) Provide a flush wall mounted enclosure for AM/FM tuner/cassette unit when not mounted in rack.

(5) Power for the unit shall come from the central enclosure.

(6) CD player to be Sony or equivalent.

D. Emergency Tone Generator

(1) Provide seven distinct tones. Tones shall be activated by emergency push button panel specified below.

(2) Emergency Tone shall go over outside horns.

(3) Emergency tones shall be distributed to all speakers

(4) Emergency tone generator included with the system.

E. Field Equipment

(1) Ceiling speakers: provide an 8" speaker with a 5 oz. magnet complete with line matching transformer. Program rating shall be 15 watts continuous.

(2) Provide a square recessed baffle with each unit. the speaker assembly shall be a DUKANE 5A606 speaker with a 6A328 grille. The backbox shall be a DUKANE 145-222.

(3) Wall speaker: provide an 8" speaker with a 5 oz. magnet complete with line matching transformer. Program rating shall be 15 watts continuous. The speaker assembly shall be a DUKANE model 6A551.
(4) Outside speaker (recessed mount): Provide a DUKANE outdoor recessed speaker. Provide speaker with a multitap line matching transformer. A swivel mount bracket will be provided to allow ease of adjustment. Units shall be weather resistant.

(5) Classroom Call Button: Provide DUKANE 9a1765 call switch mounted on a stainless steel plate.

(6) Clocks are Owner provided and Owner installed.

4. WIRING

Size and quantity of conductors shall be in accordance with manufacturer's requirement for cabling. Cables may be run in conduit or in return air plenums provided the cable is UL listed for plenum use.

5. WARRANTY AND TRAINING

A. The system contractor shall warrant any equipment installed under this specification to be free from defect for a period of one year from date of final acceptance.

B. The system contractor shall provide a minimum of four hours training for school district personnel on proper operating procedures for the system.

END OF SECTION.
SECTION 16800 - SECURITY INTRUSION DETECTION SYSTEM

1. GENERAL

Each Contractor's attention is directed to General Provisions, and all other contract documents as they may apply to his work.

A. General Requirements

(1) The Security System shall include all items, articles, materials, necessary for a complete system, including all labor, materials, cabling, equipment and incidentals necessary and required for a complete and operating security system.

(2) This contract includes consulting with the Owner as needed to coordinate receiving services, to allow proper connections to any new or existing monitoring service the Owner wishes to use. Verify these services prior to bid and include any connection costs and the first year's monitoring fee in this contract.

(3) Telephone communication to the local security service will be furnished and installed by Contractor. Provide all needed equipment, telephone lines and one year of service in this contract.

(4) All software programming will be done by Contractor. Each device shall be configured as an individual zone to the panel.

(5) Wiring charts will be provided by Contractor as to what sensor will be wired to what channel, to suit Owner's requirements.

(6) All labeling of the LED displays and control panels will be by Contractor.

(7) Extent of Intrusion-Detection security system work is indicated by drawings and schedules. This system will consist of PIR motion detectors in main movement corridors, remote arm/disarm keypads, remote annunciator/control panel, point I.D. transponders, alarm sirens, and data gathering control panel.

(8) Provide software applications for security system, capable of detecting and transmitting security breach by means of cables to data gathering panel for processing and response by panel and distribution to the remote annunciator and sirens as required, as well as off-site notification to the monitoring service as requested by the Owner.

(9) Work of this section includes wires/cables, raceways, electrical boxes and fittings, as specified in other sections of these specifications.

2. SCOPE OF THE WORK
A. The Contractor shall provide the necessary labor, materials, services and coordination with the Owner and equipment supplier to provide the complete security system indicated on the plans and specified herein. The work shall include, but is not necessarily limited to:

(1) All necessary conduit, panels, boxes, power connections, etc., as required.

(2) Cover plates, cabling, testing, terminations, adjustment of devices to ensure adequate coverage patterns.

(3) The Contractor shall insure that all work is scheduled and accomplished on a timely basis so as not to delay any other parts of the construction.

(4) Warranty on complete system, unconditional, for a period of one year from final acceptance of the installation.

3. INSTALLATION

A. The Contractor shall provide all instruments, wiring, lightning surge suppression on incoming lines and connections required for the security system.

B. The Contractor shall install conduit system as shown on plans. Contractor shall provide power connections to security devices as required. Security cables may be installed in cable tray systems where possible, and if properly rated for open tray installation in plenum areas.

C. Cabling

(1) A complete cabling system shall be furnished and installed, which shall adhere to the highest workmanlike standard of quality and appearance.

(2) All cabling shall be concealed, run in conduit from flush-mounted device outlet box to system, then home to control units thru cable tray or routed to control locations in approved conduit.

(3) Cabling may be installed outside of raceway only thru cable tray, provided it meets all N.E.C., local, state and federal fire code's and it is concealed above accessible ceilings, using plenum rated cable.

(4) Wire/cable manufacturers shall be Belden, West Penn, Alpha or approved equivalent.

(5) All cabling shall be stranded - No solid conductors will be accepted. All cabling shall be 100% shielded with appropriate drain wire and insulation.

(6) All cable connections shall be continuous run (including shield) whenever possible. Any junctions of cable conductors or shield shall be made in a metal enclosure, soldered and taped. No mechanical connections will be accepted. The size of cabling shall be a minimum of 22 gauge. All cables will be labeled (on both ends and at each junction) as to the area served with a permanent type of labeling system.
D. Electrical Wiring System

(1) Power for control panel(s) shall be fed from a circuit or circuits from an electrical
distribution panel and shall not be taken from receptacles, lighting, or equipment circuits.
The circuit(s) within the electrical distribution panels shall be marked "Security System,"
taken from the indicated 120V power panel in the building, on dedicated circuit(s).

E. Equipment

(1) Manufacturers

In order to set minimum standard of quality, operation and features/options a product brand
is named. The manufacturer ADEMCO Series VISTA 4140XMPT is specified. Alternate
equipment may be submitted for approval to bid to the Engineer in writing 10 days prior to
project bid date. Submittals must contain full engineering data, operators manual, list of
differences from the specified system, list of existing systems in operation. Any approved
systems shall be equivalent in every feature to the specified system whether or not
specifically called for herein. Subject to compliance with requirements, provide security
system products of one of the following (for each type of product):

a. Alternate Security System Manufacturers:

Ademco, Moose-Airitech, Simplex

(2) Intrusion Detection Security Systems

a. General: Provide security system, of types, sizes, capacities and electrical characteristics
indicated, consisting of addressable PIR motion detectors, remote arm/disarm keypad
with remote annunciators, data gathering panel as required, connection to Owner's
required off-site monitoring service, alarm sirens, signal transmission lines, and other
components as required for complete installation. Except as otherwise indicated, provide
manufacturer's standard security system components as indicated by published product
information, designed and constructed as recommended by manufacturer. Provide
security systems with following functional and construction features as indicated.

b. System Control Panel: ADEMCO VISTA 4140XMPT with built in digital
communicator, 12vdc 6.0 gel cell back up battery rechargeable, auxiliary power output of
12vdc 700 mA, with circuits that are thermal breaker protected. System shall be
furnished with 64 alarm receiving zones active. System shall allow customized zone
descriptions. These descriptions shall be chosen from a library of words. The display
shall be backlit for easy viewing in the dark. The system shall be capable of downloading
via modem or programmed from the keypad. Qualified service representatives shall
perform the programming of the system via modem. The system shall be capable of
supporting wireless, hardwired and multiplexed alarm zones. The system shall be
capable of up to 8 partitions as required, with up to 128 user codes, with ability to log
224 events. The system shall contain #4152LMPO loop module as required to support the multiplex cable system with #4190WH RPM end of line supervisory resistors as required. Supplier shall utilize a 4201 RPM programmer for all points in the system that do not utilize a DIP switch. Further, the system shall contain #4197 polling loop extender as required for long cable runs to support data transmission and reception.

c. Remote Consoles: Shall be ADEMCO 5137AD with a two-line. 32 character supertwist Alpha display, with custom description programmed for each protection point. The console shall have soft, backlit pushbutton keys that provide both tactile and audible feedback. The 5137 shall have a built-in sounder and two status LED's which show if power is present (Green) and system armed (Red). The unit shall be the addressable version provided with a flush mount kit number 513TRK.

d. Point I.D. Transponder: Shall be ADEMCO 419WH 2-point Remote Point Module with all zones supervised via end of line resistors.

e. Group I.D. Transponder: Shall be ADEMCO 4208 8-point Remote Point Module with all zones supervised via end of line resistors.

f. Passive Infrared Motion Detectors: Shall be ADEMCO model 4196 Quad Zone Passive Infrared Motion Detector, complete with built in RPM. This unit shall contain two twin element pyroelectric detectors and two sets of electronics to minimize false alarms. This unit shall be programmed by the #4201 RPM. These units shall be active and require power from the data gathering panel.

g. Alarm Sirens: Furnish as shown on the project drawings. Alarm sirens shall be ADEMCO model 740 High intensity sounder mounted in R440SC heavy gauge steel enclosure, with tamper proof switches. Note that this unit shall have conduit installed from the data gathering panel to the Siren enclosure and be grounded according to code requirements. Siren shall require no more than 60mA @ 6 volts DC to emit a high frequency, piercing sound. Zone sirens into the area zone configuration.

h. Sounding Devices/Sirens: Shall be ADEMCO model 747 self contained siren with a 95dB output at 12vdc.

(3) Security System Cabling And Accessories

a. Alarm Cable: Furnish and install cable as shown on the project drawings and required by local code requirements and the equipment manufacturer. The field cable shall be twisted pair minimum, #16 AWG, stranded, with outside jacket, no shield. One pair to be used for data while the other shall be used for power distribution for field alarm devices. This cable shall be N.E.C. 800 and U.L. listed for use as a security cable in an air plenum space. This cable shall be provided for all system functions including, but not limited to:

1) Multiplexed alarm zones
2) Hardwired alarm zones
3) Remote arm/disarm key pad (home run to panel)
4) Remote alarm annunciator (home run to panel)
5) Alarm siren as shown on the project plans (home run to panel)
6) Main telephone board

4. EXECUTION

A. Examination

(1) Examine areas and conditions under which Security system is to be installed, and correct conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

B. Installation Of Security Systems

(1) Install security system, including components where indicated, in accordance with equipment manufacturer's written instructions, in compliance with National Electrical Code, and with recognized industry practices, to ensure that system complies with requirements and serves intended purposes.

(2) Use care in handling, fishing and pulling-in electronic cable to avoid damage to cable and shielding. Avoid excessive and sharp bends.

(3) Install equipment properly to avoid causing mechanical stresses, twisting or misalignment of equipment being exerted by clamps, supports, and cabling.

(4) Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified on U.L. Standards 486A and B, and the National Electrical Code.

C. Grounding

(1) Provide equipment grounding connections for security system as indicated. Tighten connections to comply with tightening torques specified in U.L. lighting and standards assuring permanent and effective grounds. Provide a dedicated isolated ground from the equipment data gathering panel to the incoming main electrical service ground.

D. Adjusting And Cleaning
(1) Set field-adjustable security system components for input voltages, current settings and frequency settings. Set the I.D. numbers for the data gathering panel and the field devices. Provide a complete patching and connection map for the system, posted at the main panel location.

(2) Touch-up scratched and marred surfaces to match original finishes; remove dirt and construction debris.

E. Demonstration

(1) Upon completion of installation of security components, and after circuitry has been energized with normal power source, test security system to demonstrate capability and compliance with requirements including, but not limited to; test the operation of each alarm device, as well as the proper annunciation of that device at the remote annunciator.

(2) Contractor shall perform in-service training for the Owner's representatives for at least six hours. Contractor shall set an appointment for this training with the Owner one week in advance. Engineer shall be similarly notified of this in service training.

END OF SECTION.
SECTION 16810 - FIRE ALARM SYSTEM

1. GENERAL

A. SCOPE AND RELATED DOCUMENTS

(1) The work covered by and the intent of this section of the specifications includes the furnishing of all labor, equipment, materials, testing, programming and performance of all operations in connection with the installation of the Fire Alarm System as shown on the drawings, as herein specified and as required by the applicable codes.

(2) The requirements of all other applicable conditions of the Contract, Supplementary Conditions and General Requirements, apply to the work specified in this section.

(3) The complete installation shall conform to the applicable sections of NFPA-71, NFPA-72A, B, C, D, Local Code Requirements and National Electrical Code (Article 760). The requirements of any local fire department and the Authority Having Jurisdiction shall also be observed in the system installation and device layout.

(4) The work included in this section shall be coordinated with related work specified elsewhere in these specifications.

B. QUALITY ASSURANCE

(1) Every component, device, transmitter, software, etc., that are included in the work, to make up a complete Fire Alarm System shall be listed as a product by the manufacturer under the appropriate category by the Underwriters' Laboratories, Inc. (UL), and shall bear the "U.L." label.

(2) The system power, signal and controls wiring shall be UL listed for Power Limited Applications per NEC 760. All circuits shall be marked in accordance with NEC Article 760.

C. GENERAL

(1) Furnish and install a complete digital multiplex Fire Alarm System as described herein and as shown on the plans; to be wired, connected, completely tested, and left in first class operating condition. The system shall use individually-addressable digital multiplex device circuit(s) with individual device supervision, appliance circuit supervision, incoming normal and stand-by power supervision. In general, systems shall include a control panel, manual pull stations, automatic fire detectors, horns, flashing lights, annunciator (if indicated), raceways, all wiring, connections to devices, connections to valve tamper switches, water flow switches and mechanical controls, outlet boxes, junction boxes, and all other necessary materials for a complete, operating system.
The fire alarm control panel shall allow for loading or editing of any special instructions or operating sequences as required. No special tools, modems, or an off-board programmer shall be required to program the system to facilitate future system expansion, building parameter changes, or changes as required by local codes. All instructions shall be stored in a resident non-volatile programmable memory.

(2) All panels and peripheral devices shall be the standard product of a single manufacturer and shall display the manufacturer's name of each component. Any catalog numbers specified under this section are intended only to identify the type, quality of design, materials, and operating features desired.

The listing of specific catalog numbers and equipment parameters is not intended to limit competition among other manufacturers that propose to supply equivalent equipment and services. Fire alarm systems as manufactured by Simplex, Siemens/Cerberus, Edwards, Honeywell or Notifier will be acceptable.

(3) Equipment submissions for shop drawing review must include a minimum of the following:

a. Complete descriptive data indicating UL listing for all system components.

b. Complete sequence of operations of the system.

c. Complete system wiring diagrams for components capable of being connected to the system and interfaces to equipment supplied by others.

d. A copy of any state or local Fire Alarm System equipment approvals.

e. An Autocad (latest version) produced wiring diagram illustrating the basic floor plan of the building, showing all system wiring and equipment, as well as zoning boundaries and schedule of zone legends as intended to appear on annunciators. Provide three CD-Rom copies of as-built drawings and all system operational software at close of project, to be included in operation and maintenance manuals.

(4) No work shall be done until the drawings are approved by the Kentucky Department of Housing, Buildings and Construction.

D. OPERATION

(1) The system alarm operation subsequent to the alarm activation of any manual station, automatic detection device, or sprinkler flow switch shall be as follows:

a. 1) The appropriate initiating device circuit indicator (red color) shall flash on the control panel until the alarm has been silenced at the control panel. Once silenced, this same indicator shall latch on. A subsequent alarm received after silencing shall flash the subsequent zone alarm indicator on the control panel and resound alarms and flashing signals. These same conditions shall occur at any remote annunciator.
2) A pulsing alarm tone shall occur within the control panel until silenced.

b. All alarm indicating appliances shall sound in a temporal code pattern until silenced by an alarm silence switch at the control panel (or the remote annunciator, if any).

c. All doors normally held open by door control devices shall close. Doors shall also be released in the event of incoming normal power failure.

d. A supervised signal to notify the local fire department or an approved central station (as required by local codes) shall be activated.

e. A supervised signal shall directly activate, shut down or reconfigure the air handling systems as required by NFPA or as otherwise indicated herein. Provide necessary interlock wiring as required to control mechanical equipment.

f. The Contractor(s) shall coordinate with each other as necessary to provide all required auxiliary contacts, DDC systems interfaces, equipment, etc., as needed to shut down or otherwise control air handling systems per NFPA and all applicable codes.

g. The system shall be wired with two circuits to all Notification devices so that when an alarm is acknowledged, silencing the audibles, the visual units shall continue in operation until the main control panel has been reset. If local codes require other than this arrangement, the system shall be wired in accordance with the code that is applicable.

(2) The alarm indicating appliances shall be capable of being silenced only by authorized personnel operating the alarm silence switch at the main control panel or by use of a similar key operated switch at the remote annunciator (where remote units are provided). A subsequent alarm shall reactivate the signals. Operation of the alarm silence switch shall be indicated by trouble light and audible signal.

(3) The alarm activation of any elevator lobby shaft, pit or equipment room smoke detector shall, in addition to the operations listed above, cause the elevator cabs to be recalled according to the following sequence:

a. If the alarmed detector is in any location or on any floor other than the main level of egress, the elevator cars shall be recalled to the main level of egress.

b. If the alarmed detector is on the main egress level elevator lobby, the elevator cabs shall be recalled to the pre-determined alternate recall level.

c. Provide auxiliary contacts within the base of each elevator lobby smoke detector, with each separate landing to be wired back separately to the elevator controller. Coordinate all equipment terminations and sequence of operation with the elevator installer. The use of digital to analog controllers to accomplish this function will be acceptable, if in compliance with codes.
d. Provide heat detectors within 12" of each sprinkler head where they are installed in elevator equipment rooms, shafts or pits, in accordance with code. The temperature rating and wiring of the detectors shall be coordinated with the sprinklers, per ANSI Elevator Code and NFPA. Wire to interrupt elevator power per the applicable code.

(4) The activation of any standpipe water valve tamper switch or sprinkler zone valve tamper switch shall activate a distinctive system supervisory audible signal and illuminate a "Sprinkler Supervisory Tamper Switch" indicator at the system controls (and the remote annunciator[s]). There shall be a distinction in the audible trouble signals between valve tamper switch activation and opens or grounds on fire alarm circuit wiring.

a. Activating the trouble silence switch will silence the supervisory audible signal while maintaining the "Sprinkler Supervisory Tamper" indicator showing the tamper contact is still activated.

b. Restoring the valve to the normal position shall cause the audible signal and visual indicator to pulse at a fixed rate.

c. Activating the trouble silence switch shall silence the supervisory audible signal and restore the system to normal.

(5) Include with the control panel, as an auxiliary function, a built-in test mode that, when activated, will cause the following operation sequence:

a. The city connection circuit shall be disconnected.

b. Control relay functions shall be bypassed.

c. The control panel shall show a trouble condition.

d. The panel shall automatically reset itself.

e. Any momentary opening of an initiating or indicating appliance circuit shall cause the audible signals to sound for a minimum of two seconds to indicate the trouble condition.

(6) A manual evacuation switch shall be provided to operate the system indicating appliances and/or initiate "Drill" procedures.

(7) Activation of an auxiliary bypass switch shall override the automatic functions either selectively or throughout the system and initiate a trouble condition at the control panel.

(8) Include any and all detection equipment and interface relays as required to provide a 100% code approved and supervised pre-action Fire Suppression system. Coordinate with the Fire Protection installer as required.

E. SUPERVISION
(1) The system shall contain Class "B" (Style "B") independently supervised initiation circuits as required for the zoning indicated. Circuits shall be arranged so that a fault in any one zone shall not affect any other zone. The alarm activation of any initiation circuit shall not prevent the subsequent alarm operation of any other initiation circuit.

(2) There shall be supervisory initiation circuit(s), as required, for connection of all sprinkler valve tamper switches. Wiring methods which require any fire alarm initiation circuits to perform this function shall be deemed unacceptable; i.e., sprinkler and standpipe tamper switches (N/C contacts) shall NOT be connected to circuits with fire alarm initiation devices (N/O contacts). These independent initiation circuit(s) shall be each labeled "Sprinkler Supervisory Tamper Switch" and shall differentiate between tamper switch activation and wiring faults. Provide individual annunciation for the main post indicator valve and each tamper switch as indicated by the zoning schedule on the plans or as otherwise required by codes. For these circuits and all exterior underground copper circuit wiring, provide proper surge suppression and protection for circuit.

(3) There shall be independently supervised and independently fused indicating appliance circuits as required for alarm audible signals and flashing alarm lamps.

(4) All auxiliary manual controls shall be supervised so that all switches must be returned to the normal (automatic) position to clear system trouble.

(5) Each independently supervised circuit shall include a discrete (amber color) "Trouble" indicator to indicate disarrangement conditions, per each circuit.

(6) The incoming power to the system shall be supervised so that any power failure shall be audibly and visually indicated at the control panel and the annunciator. A green color "power on" indicator shall be displayed continuously while incoming power is present.

(7) The system batteries shall be lead-acid type, supervised so that disconnection or failure of a battery shall be audibly and visually indicated at the control panel (and the annunciator).

(8) Wiring to a remote annunciator (if provided for system) shall be supervised for open and ground conditions. An independent annunciator trouble indicator shall be activated and an audible trouble signal shall sound at the control panel.

F. POWER REQUIREMENTS

(1) The control panel shall receive 120 VAC power via a dedicated circuit. The incoming circuit shall have suitable overcurrent protection within the control panel, as well as at the circuit source. If additional circuits are required for this or other control units, they shall be provided by the Contractor.

(2) If the facility is equipped with an emergency standby power generator, the fire alarm equipment shall be connected to this system, per N.E.C.
(3) The system control panel and auxiliary equipment, such as power supplies shall be provided with sufficient battery capacity to operate the entire system upon loss of normal 120 VAC power in a normal supervisory mode for a period of time as required by codes for the building occupancy. There shall be reserve battery capacity to drive all alarm appliances for five minute indication at the end of this period. The system shall automatically transfer to the standby batteries upon power failure. All battery charging and recharging operating shall be automatic. Batteries, once discharged, shall recharge at a rate that will provide a minimum of 70% capacity in 12 hours, or sooner if required by codes.

(4) All circuits requiring system operating power shall be 24 VDC and shall be individually fused at the control panel.

(5) Power supplies for Notification signals, whether in the main panel or within remote power supply cabinets, shall be designed to provide a minimum of 20% spare capacity for future signals.

G. FIRE ALARM CONTROL PANEL

(1) Where shown on the plans, provide and install the Fire Alarm Control Panel. Construction shall be modular with solid state, microprocessor based electronics. All visual indicators shall be high contrast, light-emitting diode type.

(2) The control panel shall contain the minimum following features as per plans:

- Minimum Capacity shall support connectivity of sprinkler system monitoring and control of tamper and flow switches
- Initiation Device Circuits
- Alarm Indicating Appliance Circuit
- Supervised Annunciator Circuits
- Local Energy City Connection, if required
- Form C Alarm Contacts (2.0 Amps ea., minimum of two unless otherwise required)
- Earth Ground Supervision Circuit
- Automatic Battery Charger, of proper rating
- Standby Battery, Lead/Acid Type
- Resident non-volatile programmable operating system for all operating requirements
- Supervised Manual Evacuation Switch
- Internal power supplies as required for auxiliary functions as indicated
- Auxiliary contacts or relays for auxiliary functions as indicated
- All Custom Software and Programming as required to suit the project requirements

H. SYSTEM SOFTWARE AND PROGRAMMING

(1) Provide all programming and software necessary to place annunciators and controls in full operation. System set-up shall allow for changes in annunciator legends without rewiring or addition of programming or electronics. Furnish initial programming and reprogramming as
needed to accommodate changes in the system up to the time of system acceptance by the engineer without extra charge.

I. PERIPHERAL DEVICES

Note: On fully digital multiplex systems, provide addressable devices, bases or modules for devices listed herein. Each device shall be an individual address on the system. Addressable bases or modules shall be U.L. listed for the device served.

(1) CEILING-MOUNTED SMOKE DETECTORS, PHOTOELECTRIC TYPE, SINGLE STATION WITH 120V AND BATTERY BACK UP

a. Furnish and install where indicated on the plans or required, ceiling-mounted smoke detectors. Provide separate outlet-box mounted base with auxiliary relay, or standard base, as required.

b. Smoke Detectors shall be listed to U.L. Standard 268 and shall be compatible with their control equipment. Detectors shall be listed for this purpose by Underwriters' Laboratories, Inc. The detectors shall obtain their operating power from the fire alarm panel supervised detection loop. Loss of the operating voltage shall interrupt the supervisory circuit of the fire alarm detection loop and cause a trouble signal to be generated at the control panel. Detectors shall be capable of being reset at the main control panel.

c. No radioactive materials shall be used. Detector construction shall provide mounting base with twist-lock detector head. Contacts between the base and head shall be of the bifurcated type using spring-type, self-cleaning contacts. Removal of the detector head shall interrupt the supervisory circuit of the fire alarm detection loop and cause a trouble signal at the control panel. Detector design shall provide full solid state construction, and compatibility with other normally open fire alarm detection loop devices such as heat detectors, pull stations, etc.

d. To minimize nuisance alarms, voltage and RF transient problems, suppression techniques shall be employed as well as a smoke verification circuit and an insect screen. The detector head shall be easily disassembled to facilitate cleaning.

e. Remote LED alarm indicators shall be installed where required.

f. Smoke detectors (and all other system electronics) shall be shielded to protect circuitry from EMI problems generated by power fields, cellular phones, etc.

g. Special Note: The Contractor installing smoke detectors shall use care in the final positioning of all devices. They shall not be installed closer than 36" from an air diffuser or return grille, closer than 24" from a ceiling/wall intersection, or similar location that...
would diminish detector performance. Refer to and comply with NFPA 72E, "Standard On Automatic Fire Detectors".

(2) DUCT SMOKE DETECTORS

a. Duct smoke detectors shall be of the solid state photoelectric type, operating on the light scattering photodiode principle. The detectors shall ignore invisible airborne particles or smoke densities that are below the set alarm point. No radioactive materials shall be used. The basic construction of duct smoke detectors shall be the same as that previously described for ceiling-mounted smoke detectors. Duct housing couplings shall be slotted to insure proper alignment of the sampling and exhaust tubes. Detector shall have an alarm status LED visible through a transparent cover, panel or in housing.

b. The Contractor shall furnish air duct smoke detectors with template to the sheetmetal or air handling unit installer for installation. Coordinate length of sampling probe required and furnish appropriate length. Probe tube shall be located in accord with manufacturer's recommendations, to give maximum sampling rate of airflow. Provide multiple detectors, as required, if a single device will not provide adequate sensing due to duct size or air velocity. Wire multiple detectors on a single air handling system as a single zone or address unless otherwise required by prevailing codes. Field verify quantity of detectors needed to provide NFPA-compliant coverage of the air handling unit and provide as required.

c. Detector supervised power and alarm wiring (from F.A. control panel) is to be provided by the Contractor. Interlock wiring from auxiliary contacts to stop or otherwise control air handling unit fan motor(s) is to be provided by the Contractor. Provide auxiliary contacts as required. Zone wiring and indication for air duct smoke detectors shall be maintained separate from area detection devices. Detector shall be capable of being reset at the main control panel, and at a local test/reset station.

d. Where air duct smoke detectors are located in other than Mechanical Rooms or in spaces not easily visible, a remote alarm/power indicating LED key reset station shall be installed. These remotes shall be ganged together, if required, and labeled accurately as to which unit is reporting an alarm condition.

e. Where air duct smoke detectors are indicated to be furnished at concealed air handling units above ceilings or smoke damper locations, furnish as outlined above. Also provide remote indicating alarm LED flush in corridor wall at 7'-0" A.F.F. immediately below installation, or as close as practical to installation. The Contractor is to provide control wiring, E.P. switches, etc., as required to operate smoke dampers, as well as the required operating circuit. Coordinate all requirements with the installer of smoke dampers.

f. Ionization - type detectors shall not be utilized for air duct smoke detection.
g. All air duct smoke detector installations and materials shall be in accord with U.L., NFPA, and any other applicable codes.

(3) END OF LINE RESISTOR

a. End-of-line devices (if required) shall be flush-mounted, located at 7'-0" A.F.F. in corridor walls or as indicated.

(4) DIGITAL ALARM COMMUNICATOR/TRANSMITTER

a. Provide a U.L.-listed and NFPA-compliant digital alarm communicator/transmitter (D.A.C.T.). Install at telephone terminal board or telephone service entrance and provide supervised wiring to fire alarm control panel as required. This unit may be semi-flush mounted at the F.A.C.P. location with prior approval by the Engineer. It may also be integrated within the main control panel, if U.L.-listed for the purpose.

b. The installation and connection of the D.A.C.T. shall be in compliance with all provisions of N.F.P.A. 71 and all other applicable codes. The installation and connection shall be acceptable to the Authority Having Jurisdiction, as well as the telephone company (or companies) over whose lines the signal(s) will be transmitted. Include any costs associated with telephone company work and services required in bid. Telephone connection shall be in compliance with NFPA 71, chapter five.

c. The D.A.C.T. shall be capable of transmitting all information relative to system status changes due to alarm, trouble, water flow, and any other information as required by current codes applicable to the facility. This information shall be transmitted to a U.L. listed Central Receiving Station, that also is maintained in accord with the requirements of NFPA 71. Connect system to transmit signals as required by local codes.

d. As a part of this contract, the services of a Central Receiving Station shall be engaged for a period of one year from the date of substantial completion, this date as defined elsewhere in these documents. The Central Receiving Station facility selected shall be in full compliance with NFPA and other applicable requirements. The Contractor shall initiate this service, provided on a contract basis, and shall include any costs associated with this provision in his bid. The actual beginning date of the contract with the central receiving station may be adjusted at the discretion of the Engineer, but in no case shall be for less than one year. The contractor shall notify the owner in writing by certified mail that this service has been contracted for and explain the provisions of this service adequately. A copy of this communication and the return receipt shall be forwarded to the Architect and the Engineer.

(5) REMOTE POWER SUPPLY UNITS FOR PERIPHERAL

a. Provide remote power supply(ies) as required for proper system operation.
b. Remote power supplies shall be provided with local intelligence compatible with the
digital multiplex network, so they have a unique address, providing the ability to monitor
the supply for loss of power, shorts, grounds and other supervisory functions.

c. Where required by the fire alarm system manufacturer, remote power supplies shall be
provided that will provide sufficient current to drive audio/visual or other required
devices.

d. These units shall be located in electrical closets, mechanical rooms or similar spaces.
They shall not be installed in finished areas, storage rooms, etc., without the permission
of the Engineer. All locations shall be indicated on the shop drawing submissions.

e. Provide dedicated 120 volt power circuit(s) from nearby panelboards as required,
whether indicated on the plans or not.

J. INSTALLATION

(1) Provide and install the system in accordance with the plans and specifications, all applicable
codes and the manufacturer's recommendations. All wiring shall be in a completely separate
conduit system from power wiring or other raceway systems. Minimum conduit size shall be
3/4" trade size. Maximum wire fill shall be 40%, for any raceway system.

(2) All junction boxes shall have coverplates painted red and labeled "Fire Alarm". A consistent
wiring color code shall be maintained throughout the installation. The number of wiring
splices shall be minimized throughout. Excessive wire splicing (as determined by the
Engineer), shall be cause for rejection of the work.

(3) All circuit breakers and disconnects serving fire alarm equipment shall be marked in red and
clearly labeled as Fire Alarm Circuits.

(4) Installation of equipment and devices that pertain to other work in the contract shall be
closely coordinated with the appropriate tradesmen or other contractors.

(5) The Contractor shall clean all dirt and debris from the inside and the outside of the fire alarm
equipment after completion of installation.

(6) The manufacturer's authorized representative shall provide on-site supervision of installation,
and shall perform the initial "power-up" of the system after he has thoroughly checked the
installation.

(7) Operation and maintenance manuals submitted for this project shall list names, license
numbers, and telephone numbers of at least two installers that are employed full time by the
supplier/manufacturer to install and test fire alarm systems in the installation location.
A floor plan drawing indicating fire alarm devices and wiring only, shall be provided by the manufacturing company for job site use. These drawings shall be approved by the State Fire Marshal's Office or Local Authority Having Jurisdiction, as appropriate and in accord with code requirements. A copy of this drawing shall be submitted to the Engineer for his review, approval and project records.

K. TESTING

(1) The completed fire alarm system shall be fully tested in accordance with NFPA-72H by the contractor in the presence of the Owner's representative and the Local Fire Marshal. Upon completion of a successful test, the Contractor shall certify the test results in writing to the Fire Marshal, Owner, General Contractor, Architect and Engineer. Provide one week's written advance notice of the test to all concerned parties.

(2) All auxiliary devices the fire alarm system is connected to, including tamper switches, flow switches, elevator controls, remote receiving stations, etc., shall be fully tested for proper operation where interfacing with the fire alarm system.

(3) The Contractor shall provide a minimum of three hours of instructional time to the Owner in the operation and maintenance of all equipment and components. A receipt shall be obtained from the Owner that this has been accomplished, and a copy forwarded to the Engineer. Provide additional training time if required by the Owner at no charge to the contract or as direct charge to the Owner.

L. WARRANTY

(1) The Contractor shall unconditionally guarantee (except for vandalism or misuse) the completed fire alarm system wiring and equipment to be free from inherent mechanical, software and electrical defects for a period of one year from the date of substantial completion.

(2) The equipment manufacturer shall make available to the Owner a maintenance contract proposal to provide a minimum of two inspections and tests per year in compliance with NFPA-72H guidelines.

END OF SECTION.