SECTION 23 05 00 - BASIC MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. The requirements set out in Bidders Documents, Contract Forms, General Conditions, Supplementary General Conditions and Special Conditions apply to all work specified in the sections of this division.

B. A division is a group of related sections and a section covers one portion of the total work or requirements. It describes a particular material or product and its installation.

A section does not necessarily relate to the work accomplished by a single subcontractor. It is not the intent of the Specifications to define the work of individual trades so that a contractor can simply hand out various sections to selected subcontractors. Each contractor will subdivide the work differently among subcontractors. It is not possible for the Specifier to know which contractor may be the successful bidder and how the project will be managed.

For the above reasons, the text of sections, and the Specifications in general, are always addressed to the Contractor and not to subcontractors. The Contractor signs an agreement with the Owner to construct the project and therefore is the only one responsible to the Owner. Responsibility for the total project remains with the Contractor no matter how the work is divided among subcontractors.

C. Work covered by the Mechanical Sections of these Specifications shall include the furnishing of all materials, labor, taxes, transportation, safe working conditions, tools, permits, fees, inspections, utilities and incidentals necessary for the complete and operable installation of all mechanical systems.

D. Service Protection Guidelines: The requirements and procedures of Service Protection Guidelines (Section 01012) shall be reviewed and followed before beginning work.

E. Under these Contract Documents, the Contractor shall provide an installation that is complete in every respect. The Contractor shall include additional details or special construction as required for work indicated or specified in this section or work specified in other sections. It shall be the responsibility of the Contractor to provide all material and equipment which is usually furnished with such systems in order to complete the installation, whether mentioned or not.

F. The Contractor shall be responsible for the coordination and proper relation of his work to the building structure and to the work of all trades. The Contractor shall visit the premises and thoroughly familiarize himself with the existing site conditions, and all details of the work and the working conditions and to verify all dimensions and elevations in the field. The Contractor shall advise the Architect of any discrepancy prior to bidding. The submission of bids shall be deemed evidence of the Contractor's site visit, the verification and coordination of all existing conditions, and the inclusion of all considerations related to the existing conditions.

G. The responsibility for the furnishing of the proper equipment and/or material and the responsibility for seeing that it is installed as intended by the manufacturer, rests entirely upon the Contractor. The Contractor shall consult and request advice and supervisory assistance from the representative of the specific manufacturer for proper installation, operation, and startup. The manufacturers' published instructions shall be followed for preparing, assembling, installing, erecting, and cleaning manufactured materials or equipment. The Contractor shall promptly notify the Architect in writing

of any conflict between the requirements of the contract documents and the manufacturers' directions and shall obtain the Architect's instructions before proceeding with the work. Should the Contractor perform any such work that does not comply with the manufacturer's directions or such instructions from the Architect, he shall bear all resulting costs that may arise from any system or equipment deficiencies.

1.2 DRAWINGS AND SPECIFICATIONS

A. These Specifications are accompanied by Drawings of the building and details of the installations indicating the locations of equipment, piping, ductwork, etc. The Drawings and these Specifications are complementary to each other, and what is required by one shall be as binding as if required by both. Phase, neutral, and switch leg indications are shown only where it is considered that clarification is required and to indicate typical wiring methods required.

B. If any departures from the Drawings are deemed necessary by the Contractor, details of such departures and the reasons therefore shall be submitted to the Architect for review. No departures shall be made without prior written acceptance of the Architect.

C. The interrelation of the Specifications, the Drawings, and the Schedules is as follows: The Specifications determine the nature and setting of the several materials, the Drawings establish the quantities, dimensions, and details, and the Schedules give the performance characteristics.

D. Should the Drawings or Specifications disagree in themselves or with their counterpart, the better quality or greater quantity of work or materials shall be estimated upon, and unless otherwise directed by the Architect in writing, shall be performed or furnished. In case the Specifications should not fully agree with the Schedules, the latter shall govern. Figures indicated on Drawings govern scale measurements and large scale details govern small scale Drawings. In case of disagreement between Specifications and Drawings, see Division I of these Specifications for clarification.

E. Items specifically mentioned in the Specifications but not shown on the Drawings and/or items shown on the Drawings but not specifically mentioned in the Specifications shall be installed by the Contractor under the appropriate section of work as if they were both specified and shown.

F. Where utilized in these specifications, the following definitions of these words shall apply.

1. Furnish: To supply.
2. Install: To set in place in position for service.
3. Provide: To furnish and install.

G. The following AT&T documents (located in Volume 2) are hereby incorporated into this specification by reference:

1. AT&T-TP-76416 ..... Grounding and Bonding Requirements for Network Facilities
2. TP 76300 ..... Installation Requirements
3. TP 76400 ..... Detail Engineering Requirements
4. TP 76900 ..... Installation Testing Requirements

1.3 SUBMITTALS

A. After the Contract is awarded, but prior to proceeding with the Work, the Contractor shall obtain, check, certify, and submit complete Shop Drawings and Brochures from Manufacturers, Suppliers,

Vendors, etc., for all materials and equipment specified herein within one week. Shop Drawings are only required for new building or additions. Product Brochures are required for all Projects. Submit Shop Drawings and Brochures in sufficient time so as not to impede the progress of Work. One week will be required for the processing of Shop Drawings and Brochures in the Engineer's office, exclusive of transmittal time. This time shall be considered by the Contractor when scheduling submittal data. After the Contract is awarded, the Contractor will advise the Engineer in writing of the schedule for submission of shop drawings and product data and the persons authorized to sign submittal data on behalf of the Company.

B. The Engineer's review of Shop Drawings and Brochures shall not relieve the Contractor of the responsibility for dimensions, errors that may be contained therein, or deviations from Contract Document requirements. It shall be clearly understood that the Engineer's noting some errors but overlooking others does not grant the Contractor permission to proceed in error. Contractor shall refer to Section 15990 for all test and balance rough-in requirements. Contractor shall ascertain all equipment electrical requirements are coordinated with Division 16 and electrical drawings. Contractor shall confirm all shop drawings reflect coordination with structural and all other trades and are free of interferences. Regardless of any information contained in the Shop Drawings, the requirements of the Contract Documents shall govern and are not waived or superseded in any way by the submittal data review.

C. Before submission of Shop Drawings and Brochures, the Contractor shall certify that each Shop Drawing and each item of material or equipment complies with the Contract Documents for this Project. Such certification shall be made by the Owner, a Partner, a Corporate Officer of the Contractor, or by a person duly authorized to sign for the Contractor. Unless so certified, Shop Drawings and/or Brochures will be returned for resubmittal. Certifications shall be in the form of rubber stamp impressions or typed letter which states:

> I hereby certify that this Shop Drawing and/or brochure and the equipment and material shown on this Shop Drawing and/or Brochure complies in all respects (except as noted*) with the requirements of the Contract Documents for this Project. I further certify that all data shown herein as to performance, dimensions, construction, materials, and other pertinent items are true and correct.
>
> (Name of Contractor)_____
>
> Signed_____
>
> Position_____
>
> Date_____
>
> * Refer to exception requirements herein.

D. Quantity of Submittals: One PDF delivered by e-mail or compact disk to Engineer. For instances where physical copies are required, Submitter shall submit one set of submittals to Engineer plus the number of submittals required for records by Owner, Architect, Contractor, and Submitter unless

otherwise stipulated in the project general conditions. Submitter shall verify the number of physical copies needed by Owner, Architect, and Contractor before submitting.

E. Manner of Submittal: All electrical submittal data shall be submitted at one time. Submittal data 11" x 17" or smaller in size shall be submitted in a single PDF electronic file three-ring hard back binders which are at least 2" thick. Submittal data larger than 11" x 17" shall be submitted as full-size physical copies unless Engineer may easily read the document when it is printed from a PDF at 11" x 17" using a shrink-to-fit command. If so, Submitter may include these items in the PDF also. Submittals of scaled drawings (versus dimensioned drawings) shall be capable of being printed to scale at 8.5" x 11" or 11" x 17" from a PDF or shall be submitted as full-size physical copies. Partial or piecemeal submittals will not be accepted. The submittal format shall follow the Specification format with each major category of equipment having its own section divider referenced to the particular paragraph(s) of the Specifications. Where submittals cannot physically be contained in one binder, additional binders shall be used, each clearly marked to indicate the sequence of the submittal.

F. Submittal Title Page: Each PDF or physical submittal shall indicate on the first PDF page or front cover the following: (1) the title of the submittal, (2) the name and location of the project, (3) the names of the Architect and Engineer, (4) the name of the Contractor making the submittal, (5) the date of the submittal, and (6) the Submittal Compliance Statement.

G. Submittal Compliance Statement: Submitter shall be responsible that the Submitter has coordinated all items in the submittal with the Drawings, Specifications, and building construction, and submitted items meet or exceed the requirements of the Specifications, and will physically interchange with the item specified. Unless so certified, all documents will be returned without review. The following form shall be used.

H. Each Shop Drawing shall indicate in the lower right hand corner and each Brochure shall indicate on the front cover the following: Title of the Sheet or Brochure; name and location of the building; names of the Architect, Engineer, Contractor, Manufacturer, Supplier, Vendor, etc., the date of submittal; and the date of each correction and revision. So far as is practical, each Shop Drawing and/or Brochure shall bear a cross-reference note to the sheet number or numbers of the Contract Drawings and Specifications showing the same work. Shop Drawings and Brochures shall be prepared as follows:

1. Shop Drawings: Drawings shall be newly prepared and not reproduced from the contract documents, drawn to a scale that can be easily read and shall contain sufficient plans, elevations, sections, and isometrics to describe clearly the items in question. Drawings shall be prepared by a draftsman skilled in this type of work. All piping, equipment layouts, ductwork and similar Shop Drawings shall be drawn to at least 1/4" = 1'-0" scale.
2. Brochures: Brochures submitted to the Engineer shall be published by the Manufacturers and shall contain complete and detailed engineering and dimensional information to show that the equipment will fit into the allotted space.
3. Brochures submitted shall contain only information which is relevant to the particular equipment or materials to be furnished. Do not submit catalogs that describe several different items other than those items to be used unless all irrelevant information is marked out or relevant information is clearly marked.

I. The submittal format shall follow the Specifications format with a submittal required for each section of Division 15. The submittal shall be contained in a three-ring hard back binder. Copies of each submittal shall be three-hole punched and arranged (or folded if required) for the Engineer's filing

convenience. Provide one copy of updated TABLE OF CONTENTS and progressive-tabbed index sheets also for the Engineer's filing convenience.

J. Submittal data for each section must be complete. Partial submittals will not be reviewed. To the greatest extent possible all sections shall be submitted with the first submission. No more than three additional submissions will be allowed to complete the submittal package.

K. Any submittal that is disapproved must be resubmitted within one(1) week following notification of such disapproval. If no satisfactory material is submitted within the two-week period, the Architect reserves the right to require the Contractor to furnish items exactly as described in the Contract Documents.

L. No allowances will be made for submittals which are not made in a timely fashion or which are turned down because they do not meet the specifications. Should delivery problems arise due to the above, affecting the completion time of the project, the Contractor will furnish and install acceptable alternates until the proper materials arrive and then replace the alternate materials with the approved materials, all at no cost to the Owner. If the Contractor is not able to furnish an acceptable alternate until the proper materials arrive, he will assume all costs for furnishing and installing all alternates as directed by the Architect and/or will pay a suitable penalty for the inconvenience experienced by the Owner. This penalty will be set by the Owner based on the particular circumstances.

M. Only equipment and material brands which are specifically mentioned in the following sections of Division 22 will be considered during the submittal process.

1.4 RECORD DRAWINGS

A. The Contractor shall maintain on a daily basis at the project site a complete set of "Record Drawings", reflecting an accurate dimensional record of all buried or concealed work. The "Record Drawings" shall also consist of a set of blackline prints of the final "Signed Off" Contractor's Coordination Drawings", where required, prepared by the Subcontractors. In addition, the "Record Drawings" shall be marked to show the precise location of concealed work and equipment, including concealed or embedded piping and valves and all changes and deviations in the Mechanical work from that shown on the Contract Documents. This requirement shall not be construed as authorization for the Contractor to make changes in the layout or work without written definite instructions from the Architect. The daily "Record Drawings" shall consist of a set of blackline prints of the Contract Drawings for this Division with the Engineer's seal and Engineer's firm name removed or blacked out. Prior to commencing work, the Contractor shall obtain from the Architect a set of blackline prints to be used for the daily "Record Drawings."

B. Owner shall provide Contractor a clean set of blue paper prints for Contractor use in maintaining Record drawings.

1.5 CONTRACTOR'S COORDINATION DRAWINGS (Applies To New Building and Additions)

A. The Contractor and all Subcontractors shall prepare a complete set of "Coordination Drawings" indicating the equipment actually purchased and the exact routing for all lines such as piping, conduit and ductwork. The elevation, location, support points, load imposed on the structure at support and anchor points, and size of all lines shall be indicated. All beam penetrations and slab penetrations shall be indicated and sized and shall be coordinated. This requirement for "Coordination Drawings" shall not be construed as authorization for the Contractor or Subcontractor to make any unauthorized changes to the Contract Drawings. All Design Drawing space allocations shall be maintained, such as ceiling height, chase walls, equipment room size, etc., unless proper written authorization is

received from the Architect to change them.

1.6 OPERATING AND MAINTENANCE MANUAL

A. Prepare and submit to the Architect for delivery to the Owner one hard copy and one digital pdf file on CD of an indexed manual with complete technical data for every piece of equipment and material installed under this Contract.
   1. Complete mechanical submittals that were approved for the project.
   2. Manufacturer's installation instruction brochures.
   3. Manufacturer's local representative and/or distributor's name and address.
   4. Manufacturer's operating and maintenance brochures.
   5. Manufacturer's internal wiring diagrams.
   6. Contractor's installation wiring diagrams.
   7. Control system installation Drawings and typed control sequences.
   8. Replacement part number listings and/or descriptions including prices and source of supply.
   9. Lubrication materials required, with instructions.
   10. Valve tag list and schematic diagram.
   11. All warranties and guarantees.
   12. Testing and Balancing Report.
   13. Commissioning Report (Bind in separate three-ring binder, when specified).

B. These manuals shall include all of the listed data bound into a permanent hard-back binder identified on the cover as "Operating and Maintenance Manual". Provide a title page listing the name and location of the Building, the Owner, the Architect, the Engineers, the General Contractor, and the Trade-Contractors installing equipment represented in the brochure.

C. Contents of the manual shall be grouped in sections according to the various sections of Division 23, and shall be listed in a Table of Contents.

1.7 QUALITY ASSURANCE

A. Should the Drawings disagree in themselves or with the Specifications or with the various codes and regulations, the better quality or greater quantity of work or materials shall be assumed and estimated, and unless otherwise directed by the Architect in writing, shall be performed or furnished. In case the Specifications should not fully agree with the schedules, the latter shall govern. Figures indicated on Drawings govern scale measurements and large scale details govern small scale Drawings.

B. The Contractor shall comply with all applicable city, county, state, or federal rules, codes and ordinances.

C. None of the terms or provisions of this Specification shall be construed as waiving any rules, regulations, or requirements of these authorities.

D. A competent foreman or superintendent, initially approved by the Architect, shall be kept by the Contractor at the building to receive instructions and to act for the Contractor. Once this superintendent has been approved, no change shall be made without approval of the Architect. Architect=s and/or Owner's representatives shall have the right to observe the work at any time. The Contractor shall have a representative present when his work is being observed, and he shall give assistance, as may be required, to the Architect's representative. Recommendations made shall be promptly carried out, and all unsatisfactory material and/or workmanship shall be replaced at once, to the satisfaction of the Architect.

E. It shall be the responsibility of the Contractor to consult the Architectural Drawings and details so as to thoroughly familiarize himself with the type and quality of construction to be provided on this project.

F. The Mechanical Drawings are diagrammatic in character and cannot show every connection in detail or every pipe and duct in its exact location. These details are subject to the requirements of codes, ordinances and also electrical, structural and architectural conditions. The Contractor shall carefully investigate all electrical, structural and finish conditions and shall coordinate the separate trades in order to avoid interference between the various phases of work. Work shall be laid out so that it will be concealed in furred chases or above suspended ceilings, etc., in finished portions of the building, unless specifically noted or indicated to be exposed. Work shall be installed to avoid crippling of structural members; therefore, inserts to accommodate hangers shall be set before concrete is poured, and proper openings through floor, walls, beams, etc., shall be provided as hereinafter specified or as otherwise indicated or required before concrete is poured. All work shall be run parallel or perpendicular to the lines of the building unless otherwise noted.

G. The approximate location of each item is indicated on the Drawings. These Drawings are not intended to give complete and exact details in regard to location. Exact locations are to be determined by actual measurements at the building and will in all cases be subject to the approval of the Architect. The Architect reserves the right to make reasonable changes in the locations indicated without additional cost.

1.8 DELIVERY, STORAGE AND HANDLING

A. The Contractor shall not receive material or equipment at the job site until ready for installation or until there is suitable space provided to properly protect equipment from rust, weather, humidity, dust, or physical damage.

1.9 UTILITIES

A. The Contract Documents reflect the general location, size, and elevations of sewer line, location, size and pressure of water and other lines and manner of routing for all utilities known to be required on this project. It shall be the responsibility of the contractor to visit the site, meet with the local utility companies in order to coordinate and confirm the exact requirements for each utility to provide a complete and operative system. The bid submitted by the Contractor shall include costs for all such coordinative work, as well as any and all utility company charges and/or fees.

1.10 TEMPORARY SERVICES

A. It shall be the responsibility of the Contractor to provide a temporary system for each utility that is required during construction with all such temporary utility costs being billed to the Contractor.

1.11 GUARANTEE

A. The Contractor shall guarantee all materials and workmanship for a period of twelve (12) months after the final acceptance of work.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. The implication is that the equipment of these other manufacturers contained within the specifications will fit within the space allowed and are considered acceptable based on the quality of the product.

B. Where acceptable manufacturers are listed, only products of those manufacturers may be provided. Additionally, the product must meet all the detailed requirements of the specifications.

C. If no manufacturer's name is mentioned, the Contractor shall provide equipment and material which meet the specifications.

D. The drawings represent the manufacturer's equipment scheduled. The listing of acceptable manufacturers in the specifications is not intended to imply that all acceptable manufacturers necessarily have equipment fitting the space provided or have the same electrical, structural or other requirements as the equipment scheduled on the drawings. The Contractor shall insure that the equipment provided will meet all project requirements prior to submitting data on that equipment.

2.2 MATERIALS AND EQUIPMENT

A. All materials shall be listed, inspected, and approved by the Underwriters Laboratories and shall bear the U.L. label where labeling service is available. The label or listing of the Underwriters Laboratories, Inc. will be accepted as evidence that the materials or equipment conform to the applicable standards of that agency. In lieu of this listing, the Contractor may submit a statement from a nationally recognized, adequately equipped testing agency, indicating that the items have been treated in accordance with required procedures, and that the materials and equipment comply with all contract requirements.

B. Materials and equipment shall be new and shall be the standard catalog products of manufacturers regularly engaged in the manufacture of products conforming to these Specifications, and shall essentially duplicate materials and equipment that have been in satisfactory use at least two years prior to bid opening. Where custom or special items are required, these shall be fully described using Drawings, material lists, etc., which fully describe in detail the item proposed for use on this project.

C. All metallic materials shall be protected against corrosion. Exposed metallic parts of outdoor apparatus, structural support, etc made of ferrous metals not made from hot dipped galvanized steel shall be or zinc-coated in accordance with ASTM A123 or A153, except where other equivalent protective treatment is specifically approved in writing.

D. Capacities shall be not less than those indicated but shall be such that no component or system becomes inoperative or is damaged because of start-up or other overload conditions. Where approved equipment requires electrical power other than those used for design purposes, the Contractor shall be responsible to adjust protective devices, starter sizes, conductors, conduits, etc. to accommodate this approved device electrically.

E. Each major component of equipment shall have the manufacturer's name, address, and catalog number on a plate securely attached to the item of equipment. All data on nameplates shall be legible at the time of final inspection.

F. All pipe, fittings, appurtenances, and other material required for complete installation of these systems shall be new to conform to manufacturer's recommendations, unless otherwise specified. All equipment injured or damaged in transit from factory, during delivery to premises, while in storage on premises, while being erected and installed, and while being tested, until time of final completion,

shall be replaced by this Contractor without extra cost to the Owner. Scratched equipment shall be repainted with factory paint to match existing or cold galvanized as required.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide and install unions or flanges at proper points to permit removal of pipe and various equipment and machinery items without injury to other parts of system. No union or flange will be required in welded lines or lines assembled with solder joint fittings, except at flanged valve or union connected equipment items, machinery items, and other special pieces of apparatus. Unions in 2" and smaller ferrous lines shall be 300 lb. AAR, malleable iron unions with iron to brass seats, and 2-1/2" and larger shall be ground flange unions. Unions in copper lines shall be 125 lbs. ground joint brass unions, or 150 lbs. brass flanges, if required by the matching item of equipment. Companion flanges on lines at various items of equipment, machines and pieces of apparatus, shall serve as unions to permit removal of the particular items. Unions or flanged devices connecting ferrous pipe to copper or brass pipe shall be dielectric type.

B. All equipment shall be installed in a manner to permit access to parts requiring service without disassembly of piping mains and other equipment. Access panels or doors shall be coordinated with the Architect and provided where necessary to permit valve equipment service or removal.

Access doors shall be Karp Associates, Inc. Type DSC-214M of types and sizes required to permit access to and service of valves. Access door shall be of style required for the wall or ceiling material. Access doors shall have the same UL rating as the ceilings, walls or partitions they are to be installed in. Frame shall be 16 gauge prime coat steel and door 14 gauge prime coat steel. Flange of frame shall be one piece construction, ¾" wide. Hinges shall be concealed, continuous piano hinge. Where space conditions prevent door swinging open, provide removable door with lift off hinges or screws. Locks shall be flush, screwdriver operated steel cam and studs. Anchor straps shall be included on all frames to be installed in masonry. Finish shall be prime coat of rust inhibitive baked grey enamel.

C. Any large piece of apparatus which is to be installed in any space in the building, and which is too large to permit access through stairways, doorways, shall be brought to the job and placed in the space and reassembled. Following placement in the space, such apparatus shall be thoroughly and completely protected against damage.

D. This contract includes many different systems furnished and installed by different trades. Each trade shall coordinate their work with that of all other trades so that it may be installed in the most direct and workmanlike manner without hindering or handicapping any other trades. Where space requirements conflict, the following order of precedence shall, in general, be observed:

1. Building lines.
2. Structural members.
3. Soil and drain piping.
4. Vent piping.
5. Refrigerant piping.
6. Condensate piping.
7. Electrical bus duct.
8. Supply ductwork.
9. Exhaust, return, and outside air ductwork.
10. Fire sprinkler piping.

11. Circulating water piping.
12. Domestic hot and cold water piping.
13. Natural gas piping.
14. Electrical conduit.

E. Provide warning tape on any piping which is crossing the equipment maintenance access area.

F. Housekeeping pad

1. Each piece of floor-mounted equipment shall be set on a structural grade concrete base. Bases shall be not less than 6" high and shall be dowelled into the floor or poured monolithic. Refer to architectural specifications for additional construction requirements.

G. Contractor shall not run hydronic and plumbing piping over telephone or electrical equipment. All piping within telephone or electrical room shall be provided with fully welded galvanized pan with moisture sensor for alarm thru BMS. The pan shall extend 6 inch beyond the piping/insulation surface.

H. Contractor shall not run conduit, raceways, piping, ductwork, etc. in such a manner as to block access to various mechanical, plumbing, or electrical equipment such as chillers, boilers, air handling units, cooling towers, pumps, fire and smoke dampers, exhaust fans, switchgear, switchboards, panelboards, etc., and their associated components.

3.2 SPECIAL REQUIREMENTS FOR WORK IN CENTRAL OFFICES

A. When possible maintain a 6" clearance between cable and fiber trays/racks, etc.

B. Ay disruption/alteration of the facility operation shall be coordinated with the Owner in advance. Such disruptions shall be minimized by at least: ensuring that the existing systems, disrupting facility operation at times with the lowest adverse impact, and having crews/materials ready and strategically placed before disrupting facility operation.

C. Position each air device/air device drop on the center of each aisle as shown. Provide transitions and offsets as necessary, to avoid conflicts with cable trays, lights, conduits, etc.

D. Provide ladder-stops as required to prevent damaging the mechanical ductwork/equipment. Coordinate ladder-stop locations on site.

E. Drilling and cutting operations shall be accomplished inside full height containment zone unless otherwise specifically approved by Owner.

F. Where drilling and cutting is approved without a dust containment enclosure, utilize a vacuum cleaning process that will assure that no dust will be dispersed in the space.

3.3 EXCAVATION AND BACKFILL

A. Prior to any excavation, the Contractor shall have all utilities marked. The Contractor shall perform all excavation of every description required in the execution of his work. Excavation shall be through whatever substance encountered, to the depths indicated on the Drawings, or as required. Excavated material suitable for backfill shall be piled in an orderly manner a sufficient distance from the trench to prevent overloading sides and cave-ins. Excavated materials not suitable for backfill

shall be removed from the site or stored as directed. Grading shall be done to protect the excavation from surface water. Trenches shall be maintained in a dry condition by bailing, pumping, or other approved methods. Pipe shall not be laid in wet trenches. Sheeting and shoring shall be provided as required for the protection of the work and the safety of personnel.

B. Trenches shall be of the necessary width and depth to provide for proper laying of pipe and appurtenances, with banks as nearly vertical as possible. Bottoms of trenches shall be excavated to the grade and depth indicated or required, and barrel of pipe shall be laid on a minimum 12 inch sand bed. Bell holes, of a size to permit proper make-up of grading, shall be provided as required. For projects located over the Edward's Aquifer Re-Charge Zone, comply with City of San Antonio Plumbing Code requirements. Existing underground piping shall be protected from damage during excavation and backfilling, and if damaged, shall be repaired to the Architect's satisfaction, at the Contractor's expense. Provide 3,000 pound concrete of 3" minimum enclosure around lines that cross electrical utility lines or telephone cables.

C. Trenches shall not be backfilled until all required tests have been performed. This requirement does not preclude sectional testing and backfilling of the various systems. Trenches shall be carefully backfilled with approved sand, free from large earth clods, rocks, and/or foreign materials, laid in 6" layers, moistened thoroughly, and carefully rammed to an elevation of one foot above top of pipe. The remainder of the backfill to finish grade shall be placed in one foot layers soaked with water, and well tamped. Under roadways, backfill to bottom of road bed material with sand only. Where settlement occurs, trenches shall be re-opened to depth required for proper compaction, refilled, and compacted.

D. Open trenches abutting foundation or basement excavations, building walls, and grade beams, will not be permitted, but shall be backfilled and completed, for a distance of not less than 10' from the above features, as soon as possible. All damage resulting from flooding or other stresses due to open trenches shall be paid for by the Contractor.

E. Where excavation requires, existing walks, street, drives, or other existing pavement to be cut to install new lines and to make new connections to existing lines, the size of the cut shall be held to a minimum, consistent with the work to be accomplished. After the installation of the new materials is completed and the excavation has been backfilled, the paving shall be patched, using materials to match those cut out. The patches shall be thoroughly bound with the original surfaces, and shall be level with them.

3.4 CUTTING AND PATCHING

A. Where it becomes necessary to cut through any wall, floor, or ceiling to permit installation of any work under this section of the Specifications or to repair any defects that may appear, up to the expiration of the guarantee period, such cutting shall be done under the supervision of the Architect by the Contractor. The Contractor shall not be permitted to cut or modify any structural members without the written permission of the Architect.

B. Patching of all openings cut by the Contractor, or repairing of any damage to the work of other trades occasioned by cutting operations, or occasioned by the failure of any part of work installed under this contract, shall be performed by the trade whose work is involved, but shall be paid for by the Contractor.

C. Any openings cut through exterior walls or roofs shall be provided with suitable covers, while they are left open, to protect the property or materials involved. Any openings cut through walls below grade shall be properly protected to prevent entrance of water or other damaging elements.

3.5 HOISTING, SCAFFOLDING, AND TRANSPORTATION

A. The Contractor shall provide his own hoisting facilities and scaffolding to set his materials and equipment in place, as indicated on Drawings and for subsequent cleaning, testing, and adjusting.

B. The Contractor shall provide necessary transportation to facilitate the delivery of all materials, equipment, tools, and labor to the job, in accordance with intent of these documents.

3.6 CLEANING

A. The Contractor shall, at all times, keep the premises free from accumulations of waste material or rubbish caused by him, his employees, or his work. This debris shall be removed, not only from the building, but also from the project site.

B. At completion of the job, the Contractor shall remove all of his tools, scaffolding, and surplus materials. He shall leave the outside area "broom clean" and inside area "vacuum clean".

3.7 ELECTRICAL WIRING OF MOTORS AND EQUIPMENT

A. Unless specifically shown, indicated, or specified to the contrary, each item shown or required by the Mechanical Drawings or specified in the Mechanical Specifications shall be accompanied by all motors necessary for the items proper operations. These motors shall be integrally attached to and/or installed with their associated equipment item and electrically connected as specified in Division 16 - Electrical. Equipment controlled from motor control centers shall be supplied with motors only. Motor control centers are specified in Division 16 and shown on the Electrical Drawings.

3.8 DEMOLITION AND RELOCATION

A. Prior to beginning any work, or preparing of any work, the Contractor shall review and implement actions required by the Service Protection Guidelines.

B. The Contractor shall modify, remove, and relocate all materials and items so indicated on the Drawings or required by the installation of new facilities. All removals and/or dismantling shall be conducted in a manner as to produce maximum salvage. Salvage materials except asbestos shall remain the property of the Owner, and shall be delivered to such destination as directed by the Owner. Non-salvageable materials and equipment shall become the property of the Contractor and removed from the site.

C. The Contractor shall immediately notify the Owner of any area where the Contractor suspects or becomes aware of the existence of asbestos or other potentially hazardous materials on this project. The Contractor shall not remove or disturb asbestos or other potentially hazardous substances until he has obtained approval in writing from Project Manager to proceed with work.

D. All items which are to be relocated shall be carefully removed in reverse to original assembly or placement and protected until relocated. The Contractor shall clean and repair and provide all new materials, fittings, and appurtenances required to complete the relocation and to restore to good operative order. All relocations shall be performed by workmen skilled in the work and in accordance with standard practice of the trades involved. Where items scheduled for relocation and/or reuse are found to be in damaged condition before work has been started on dismantling, the

Contractor shall call the attention of the Owner to such items and receive further instructions before removal. Items damaged in repositioning operations are the Contractor's responsibility and shall be repaired or replaced by the Contractor as approved by the Owner, at no additional cost to the Owner or the Architect. The Contractor may, at his discretion, and upon the approval of the Owner, substitute new materials and items of like design and quality in lieu of materials and items to be relocated.

E. Service lines and wiring to items to be removed, salvaged, or relocated shall be removed to points acceptable to the Owner. Service lines and wiring not scheduled for reuse shall be removed to the points at which reuse is to be continued or service is to remain. Such services shall be sealed, capped, or otherwise tied-off or disconnected in a safe manner acceptable to the Owner.

F. The Contractor before beginning work in existing areas shall send proper notices and receive written permission from the Owner to enter the areas, shall make necessary arrangements and perform other services required for the care, protection, and in-service maintenance of all mechanical, plumbing, electrical, communications and fire protection systems. The Contractor shall provide temporary or new services to all existing facilities as required to maintain their proper operation when normal services are disrupted as a result of the work being accomplished under this project. Outages of services as required by the new installations will be permitted but only at a time approved by Owner. The Contractor shall allow the Owner two weeks in order to schedule required outages. The time allowed for outages will not be during normal working hours unless otherwise approved by the Owner. All costs of outages, including overtime charges, shall be included in the contract amount.

G. Where existing construction is removed to provide working and extension access to existing utilities, Contractor shall remove doors, piping, conduit, outlet boxes, wiring, light fixtures, air conditioning ductwork, and equipment, etc. to provide this access and shall reinstall same upon completion of work in the areas affected.

H. Where partitions, walls, floors, or ceilings of existing construction are indicated to be removed, the Contractor shall remove and reinstall in locations approved by the Architect all devices required for the operation of the various systems installed in the existing construction. This is to include but is not limited to temperature control system devices, electrical switches, relays, fixtures, piping, conduit, etc.

I. The Contractor shall carefully measure existing facilities before preparing Shop Drawings.

3.9 INCIDENTAL ITEMS Contractor shall include in Contractor’s scope of work the removal, storage, and replacement of incidental items (such as lighting fixtures) that must be temporarily removed when new ductwork or piping is installed.

END OF SECTION 23 05 00

SECTION 23 05 13 - MOTORS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Motors: Furnished and installed under Division 23.

B. Related Work: VFD for Division 23 new equipment shall be specified under Division 26, furnished and installed under Division 26. Refer to Division 26 for more details

1.2 GENERAL

A. Submit manufacturer's product data for motors with each specific item of equipment. Data shall include motor horsepower, efficiency, voltage, phase, frequency, winding type/ configuration, and dimensional data.

B. Submit certification that equipment complies with IEEE Standard 519.

1.3 REFERENCE STANDARDS AND QUALITY ASSURANCE

A. NFPA-70, National Electrical Code.

B. NEMA MG1, Motors and Generators.

C. NEMA MG10, Energy Management Guide for Selection and Use of Polyphase Motors.

D. UL 674, Electric Motors and Generators for use in Division 01 Hazardous (Classified) Locations.

E. UL 1004, Electric Motors.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Motors

1. Baldor.
2. General Electric.
3. Magnetek.
4. Marathon.
5. Reliance.
6. Square D.
7. U.S. Electric Motors.
8. ABB.
9. Lincoln Electric Motor Division.

2.2 MOTORS

A. For alternating current, fractional and integral horsepower motors, NEMA Publication MG1 shall apply. NEMA MG10 shall apply for energy management selection of polyphase motors.

B. Voltage ratings shall be as follows:

1. Single phase:

   a. Motors connected to 120 volt systems: 115 volts.
   b. Motors connected to 208 volt systems: 200 volts.
   c. Motors connected to 240 volt systems: 230/460 volts, dual connection.

2. Three phase:

   a. Motors connected to 208 volt systems: 200 volts.
   b. Motors, less than 100 HP, connected to 240 volt or 480 volts systems: 230/460 volts, dual connection.
   c. Motors, 100 HP or larger, connected to 240 volt systems: 230 volts.
   d. Motors, 100 HP or larger, connected to 480 volt systems: 460 volts.

C. Number of phases shall be as follows:

1. Motors, less than .75 HP: Single phase.
2. Motors, .75 HP and larger: 3 phase.
3. Exceptions:

   a. Hermetically sealed motors.
   b. Motors for equipment assemblies, less than one HP, may be single phase provided the manufacturer of the proposed assemblies cannot supply the assemblies with three phase motors.

D. Horsepower ratings shall be adequate for operating the connected loads continuously in the prevailing ambient temperatures in areas where the motors are installed, without exceeding the NEMA Standard temperature rise for the motor insulations.

E. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting and running torques.

F. Bearings:

1. Motors shall be equipped with pre-lubricated steel ball or roller bearings.
2. Bearings shall have a rated fatigue life of 26,280 hours (L-10 minimum) assuming bearing load calculated with the minimum NEMA pulley size so located that the centerline of the belt load is at the end of the NEMA standard shaft extension (worst condition).
3. Bearings housings shall be equipped with grease openings for simultaneously adding new grease and purging the old grease. Provide corrosion resistant plugs or caps on grease openings which are easily accessible.

4. Rotating shaft seals or slingers at both fan and shaft ends shall be provided to prevent entry of contaminants and prevent grease leakage.
5. Bearings in motors controlled by variable frequency drives shall be guaranteed against premature bearing failure caused by discharge current. All motors controlled by variable frequency drives shall be provided with an internal shaft grounding device.

G. Motor insulation shall be NEMA Design B for standard duty motors. Severe duty motors shall have Class F insulation. Temperature rise will be in accordance with NEMA limits for class of insulation, service factor, and enclosure specified. Unless otherwise noted, motors shall be rated for 40°C ambient temperature. Motors scheduled for use with a variable frequency drive shall have spike resistant windings and shall be rated for inverter duty in compliance with NEMA MG-1, Part 31.

H. Motor enclosures shall be open drip-proof construction, except where exposed to the weather where they shall be splash-proof with rodent screens. Where adverse vapors or dust conditions prevail, enclosures shall be totally-enclosed, or totally-enclosed fan-cooled. In explosive atmospheres, explosion-proof fan-cooled enclosures with non-spark fans shall be provided. Motor frames shall be of heavy duty construction using steel, aluminum or cast iron. End brackets shall be of cast iron or aluminum construction. Aluminum must have steel inserts in the bearing cavity. Severe duty motors shall be cast iron construction (frame, end brackets and terminal box) and have all external hardware including fan and fan cover plated to prevent corrosion or be of corrosion resistant material. The air gap surfaces shall be coated with epoxy or zinc chromate to resist corrosion.

I. Polyphase motors shall be NEMA Premium Efficiency compliant, squirrel cage design with NEMA Design B or NEMA Design E locked-rotor, break-down and pull-out torque as standard unless otherwise specified. For heavy inertia loads, provide motors having design torque characteristics. All motors shall have a minimum service factor of 1.15.

J. Motor sizes as indicated on the drawings are for guidance purposes only, and is not intended to limit the equipment size.

K. Motor loading under normal conditions shall not exceed the motor nameplate loads, at applied temperature. Motors shall not be selected to operate within the service factor range of the motor.

L. Motor enclosures shall be thoroughly cleaned and painted at the factory with manufacturer's prime coat and standard finish. Special painting shall be as specified.

M. Motor speeds shall be nominally 1800 RPM when applied to a 60 Hz system.

N. Belts, chains, pulleys, couplings, motor shafts, gears and other moving parts shall be enclosed and guarded. The guards shall be metal, not less than No. 14 gage, and removable for servicing of the motors without disassembling any pipes or fittings.

O. Energy Efficiency:

1. Motors will have a power factor rating at full load and rated voltage of at least 90 percent. If a motor draws less than 1000 watts at full load, it is excluded from the 90 percent power factor (P.F.) requirement.
2. Motors shall be NEMA Premium Efficiency Type. Purchased motors must be tested and rated according to NEMA guidelines using IEEE Standard 112.
3. The minimum full load efficiency (P.F. x Eff.) shall meet or exceed the values below:

MOTOR HORSEPOWER	NOMINAL FULL-LOAD EFFICIENCY					
	OPEN DRIP-PROOF MOTORS			TEFC MOTORS		
	6 POLE	4 POLE	2 POLE	6 POLE	4 POLE	2 POLE
1	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2	87.5	86.5	85.5	88.5	86.5	85.5
3	88.5	89.5	85.5	89.5	89.5	86.5
5	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10	91.7	91.7	89.5	91.0	91.7	90.2
15	91.7	93.0	90.2	91.7	92.4	91.0
20	92.4	93.0	91.0	91.7	93.0	91.0
25	93.0	93.6	91.7	93.0	93.6	91.7
30	93.6	94.1	91.7	93.0	93.6	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93.0	94.1	94.5	93.0
60	94.5	95.0	93.6	94.5	95.0	93.6
75	94.5	95.0	93.6	94.5	95.4	93.6
100	95.0	95.4	93.6	95.0	95.4	94.1
125	95.0	95.4	94.1	95.0	95.4	95.0
150	95.4	95.8	94.1	95.8	95.8	95.0
200	95.4	95.8	95.0	95.8	96.2	95.4
250	95.4	95.8	95.0	95.8	96.2	95.8
300	95.4	95.8	95.4	95.8	96.2	95.8
350	95.4	95.8	95.4	95.8	96.2	95.8
400	95.8	95.8	95.8	95.8	96.2	95.8
450	96.2	96.2	95.8	95.8	96.2	95.8
500	96.2	96.2	95.8	95.8	96.2	95.8

P. Additional requirements for specific motors, as indicated in other sections, shall also apply.

PART 3 - EXECUTION

3.1 MOTOR INSTALLATION

A. Where applicable Contractor shall:
1. Install loose motor on base.
2. Install pulleys and belts.
3. Adjust belt tension.
4. Install necessary internal wiring.
5. Adjust speed on driven device to obtain prescribed capacity.

6. Check motor load electrically to determine the motor is not overloaded when the driven device is operating at prescribed capacity.

3.2 GUARANTEE

A. Guarantee labor, equipment, and materials for a period of one year from the date of final acceptance by the Owner.

END OF SECTION 23 05 13

SECTION 23 05 23 - VALVES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Gate Valves.

B. Globe Valves.

C. Check Valves.

D. Ball Valves.

E. Butterfly Valves.

F. Circuit Balancing Valves.

G. Plug Valves.

H. Appliance Valves.

1.2 SUBMITTALS

A. Submit manufacturer's product data by valve type listed in these specifications showing dimensions, sizes, materials, and pressure rating.

B. Submit valve schedule identifying by service the valve type to be used as listed in these specifications, size, pressure rating, class, manufacturer, figure number and purpose.

1.3 QUALITY ASSURANCE

A. Provide valves of same manufacturer throughout where possible.

B. Provide valves with manufacturer's name and pressure rating clearly marked on outside of body.

C. Valves shall be manufactured in the United States. Valve submittals shall be accompanied by a notarized letter verifying country of origin and signed by an officer of the valve manufacturing company.

D. Grooved end valves shall be of the same manufacturer as the adjoining couplings.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Gate Valves:

1. Hammond.
2. Milwaukee.

3. Stockham.

B. Globe Valves:

1. Hammond.
2. Milwaukee.
3. Nibco.
4. Stockham

C. Check Valves:

1. Victaulic.
2. Hammond.
3. Milwaukee.
4. Nibco.
5. Stockham.
6. Mueller.

D. Ball Valves:

1. Victaulic.
2. Apollo.
3. Hammond.
4. Jamesbury.
5. Milwaukee.
6. Nibco.
7. Stockham.
8. Watts

E. Butterfly Valves:

1. Victaulic.
2. Hammond.
3. Jamesbury.
4. Milwaukee.
5. Nibco.
6. Mueller

F. Circuit Balancing Valves:

1. Victaulic.
2. Armstrong.
3. Tour and Anderson.
4. Flow Set.
5. Nibco.
6. Taco

G. Plug Valves:

1. Armstrong.
2. Rockwell.
3. Grinnell.

4. DeZurik

2.2 VALVE CONNECTIONS AND ACCESSORIES

A. Provide valves suitable for connection to adjoining piping. Use line size valves unless otherwise indicated.
B. Provide threaded ends for valves 2 inches and smaller.

C. Provide flanged or grooved ends for valves 2 1/2 inches and larger.

2.3 GATE VALVES

A. Type A: Class 200, ASTM B-62 bronze body, solid disc and union bonnet, stainless steel seat rings, solid disc or seat rings, rising stem of bronze ASTM B-61, copper silicon alloy ASTM B-371 alloy 694 or machined bronze alloy containing less than 15% zinc, threaded ends, malleable handwheels. Stockham B-132, Hammond IB-651, Nibco T-174SS.

B. Type B: Class 300, ASTM B-61 bronze body and union bonnet, rising stem of bronze ASTM B-61, copper silicon alloy ASTM B-371 alloy 694 or machined bronze alloy containing less than 15% zinc and listed in MSS-SP80, stainless steel solid disc or seat rings, threaded ends, malleable handwheel. Stockham B-145, Hammond IB-654, Nibco T-174SS.

C. Type C: Class 125, ASTM A-126 Class B cast iron body solid disc and bolted bonnet, brass ASTM B-16 or copper silicon alloy ASTM B-584 alloy 875 rising stem, outside screw and yoke, bronze mounted, flanged ends. Stockham G-623, Hammond IR-1140, Nibco F-6170.

D. Type D: Class 250, ASTM A-126 Class B cast iron body solid disc and bolted bonnet, brass ASTM B-16 or copper silicon alloy ASTM B-584 alloy 875 rising stem, outside screw and yoke, bronze mounted, flanged ends. Stockham F-667, Hammond IR-330, Nibco F-667-0.

SERVICE	GATE VALVE TYPE	
	2-1/2" and Under	3" and Larger
Steam and Cond. up to 100 psig	A	C
Steam and Cond. up to 200 psig	B	D

2.4 GLOBE OR ANGLE VALVES

A. Type A: Class 150 ASTM B-62 bronze body and union bonnet, rising stem of bronze ASTM B-62, copper silicon alloy ASTM B-371 alloy 694 or machined bronze alloy with less than 15% zinc content and listed in MSS-SP80, replaceable Teflon disc, threaded ends. Stockham B-22, Hammond IB-413T, Nibco T-235Y straight pattern. Stockham B-222T, Hammond IB-454T, Nibco T-335Y angle pattern.

B. Type B: Class 300, ASTM B-61 bronze body and union bonnet, rising stem of bronze ASTM B-61, copper silicon alloy ASTM B-371 alloy 694 or machined bronze alloy with less than 15% zinc content and listed in MSS-SP80, stainless steel plug and seat, threaded ends. Stockham B-74, Hammond IB-444, Nibco T-276 A-P straight pattern.

C. Type C: Class 125 ASTM A-126 Class B cast iron body and bolted bonnet, copper silicon alloy ASTM B-584 alloy 875 or brass ASTM B-16 rising stem, outside screw and yoke, renewable seat and disc, bronze mounted flanged ends. Stockham G-512, Hammond IR-116, Nibco F-718-B.

D. Type D: Class 250, ASTM A-126 Class B cast iron body and bolted bonnet, copper silicon alloy ASTM B-584 alloy 875 or brass ASTM B-16 rising stem, renewable seat and disc, bronze mounted, flanged ends. Stockham F-532, Hammond IR-313, Nibco F-768 B.

E. Provide globe or angle globe valves as follows:

SERVICE	GLOBE OR ANGLE	
	2-1/2" and Under	3" and Larger
Chilled Water	A	C
Hot Water	A	C
Condenser Water	A	C
Steam & Cond. up to 100 psig	A	C
Steam & Cond. up to 200 psig	B	D

2.5 CHECK VALVES

A. Type A: Class 150, ASTM B-62 bronze body, Teflon disc, T-pattern, swing check design, threaded ends. Hammond IB-946, Nibco T-433Y, Jenkins 141, Grinnell 3330.

B. Type B: Class 200, ASTM B-61 bronze body, regrinding bronze disc, Y-pattern swing check design, threaded ends. Stockham B-345, Hammond IB-944.

C. Type C: Class 300, ASTM B-61 bronze body, regrinding bronze disc, Y-pattern, swing check design, threaded ends. Stockham B-375, Hammond IB-949, Nibco T-473 B.

D. Type D: Class 125, ASTM A-126 Class B cast iron body, bolted cap, bronze disc, bronze mounted, swing check design, flanged ends. Stockham G-931, Hammond IR-1124, Nibco F-918 B.

E. Type E: Class 250, ASTM A-126 Class B cast iron body, bolted cap, bronze disc, bronze mounted, swing check design, flanged ends. Stockham F-947, Hammond IR-322, Nibco F-968 B.

F. Type F: 230-psig CWP, ASTM A-536, Grade 65-45-12 ductile iron body with grooved ends or Class 125, ASTM A-126 Class B cast iron wafer style body, stainless steel, coated ductile iron, or bronze disc, Type 316 stainless steel spring, bronze, EPDM, or Buna-N seat, nonslam design. Stockham WG-970, Hammond IR-9253, Nibco W-920-W, Victaulic Series 716 and W715.

G. Provide check valves as follows:

SERVICE	CHECK VALVE TYPE	
	2-1/2" and Under	3" and Larger
Chilled Water	A	F
Hot Water	A	F
Condenser Water	A	F
Steam & Cond. up to 100 psig	B	D
Steam & Cond. up to 200 psig	C	E

2.6 BALL VALVES

A. Type A: Bronze three piece body, stainless steel ASTM A-276 Type 316 ball and stem, reinforced Teflon seat, equal to Nibco T-595-Y-66 Series, Hammond 8503, Apollo 77 Series.

B. Type B: Stainless steel three piece body ASTM A351, Grade CF8M, stainless steel stem and ball, full port, PTFE seats, with Vic-Press ends. Victaulic Series P569.

C. Provide ball valves as follows:

SERVICE	BALL VALVE TYPE 2-1/2" and Under
Chilled Water	A, B
Hot Water	A, B
Condenser Water	A, B
Fuel Oil	A

2.7 BUTTERFLY VALVES

A. Type A: Full threaded lug body, lever operated, cast or ductile iron body suitable for a maximum working pressure of 150 psig, aluminum bronze disc, stainless steel stem, EPDM field replaceable seat, waterway must be clear of all bolts or pins, Hammond 6211, Nibco LD-2000.

B. Type B: Grooved end, ductile iron body, for a maximum working pressure of 300 psig., type 416 or 316 stainless steel shafts, aluminum bronze, stainless steel, or coated ductile iron disc, EPDM pressure responsive seat or disc mounted seal. (Shaft shall be offset from the disc centerline to provide complete 360-degree circumferential seating with positive contact between the seal and disc only occurring upon valve shut-off.) Victaulic Vic300 MasterSeal and AGS-Vic300, Hammond 4500, Milwaukee, Nibco.

C. Provide butterfly valves as follows:

SERVICE	BUTTERFLY VALVE TYPE 3" And Above
Chilled Water	A or B
Hot Water	A or B
Condenser Water	A or B

D. All butterfly valves shall be suitable for dead end service in both directions without a downstream flange. Manufacturer shall supply certification to indicate that valves meet these requirements. Letter must be supplied with valve submittals.

2.8 CIRCUIT BALANCING VALVES

A. Type A: Victaulic Series 786 / 787 or Armstrong CBV-T Balancing Valves with provision for connecting a portable Differential (Ft. of Hd.) Pressure Meter. Each meter connection shall have positive shut-off valves.

1. The circuit balancing valves shall be Globe Style and all metal parts of nonferrous, pressure die cast, DZR brass nonporous Ametal Copper Alloy. Each valve shall be capable of installation in any direction without affecting flow measurement and shall provide four (4) functions:

    a. Precise flow measurement.
    b. Precisions flow balancing.

c. Positive shut-off with no drip seat and teflon disc.
d. Drain connection with protective cap.

2. Victaulic Koil-Kits Series 799, 79V, 79A, and 79B may be used at coil connections. The kit shall include a Series 786/787/78K circuit balancing valve, Series 78Y Strainer-Ball or Series 78T Union-Ball valve combination, Series 78U Union-Port fitting, and required coil hoses. A Style 793 and/or 794 differential pressure controller shall be provided as required. A meter shall be provided by the valve manufacturer that shall remain with the building owner after commissioning.

B. The valves shall have four (4) 360° adjustment turns of handwheel for maximum vernier-type setting with "Hidden Memory" feature to program the valve with precision Tamper-Proof balancing setting.

1. Each valve is to be shipped in a 4.5 R factor polyurethane container that doubles as insulation after valve is installed.

Type B: Taco type ACUF circuit balancing valves with provision for connecting a portable Differential (Ft. of Hd.) Pressure Meter. Each meter connection shall have positive shut-off valves.

2. The circuit balancing valves shall be Venturi type, and provide three (3) functions:

a. Precise flow measurement.
b. Precision flow balancing.
c. Positive shut-off with no drip seat.

SERVICE	CIRCUIT BALANCING VALVES	
	2" and Under	2-1/2" and Larger
Chilled and Hot Water	A or B	A or B

2.9 VALVE OPERATORS

A. Provide cast or malleable iron handwheels for globe, or angle, drain valves, and inside hose bibbs.

B. For butterfly valves provide cast iron gear operators and handwheels for sizes 8 inches and larger. For smaller sizes provide lever handle, infinitely adjustable with lock nut and memory stop. Provide hot dipped galvanized extension stems, valve handles and gear actuators outdoors. Provide weatherproof galvanized cast iron gear operators for valves mounted outdoors.

C. Provide valves located more than 7 feet from floor in equipment room areas with chain operated sheaves. Extend chains to about 5 feet above floor and hook to clips arranged to clear walking aisles.

D. Provide extension stems for ball and butterfly valves installed in insulated lines so that handle operation does not damage the insulation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install globe valves with stems upright within 15 degrees of vertical, not inverted. Butterfly valves shall be mounted with the stem horizontal whenever possible. Bottom half of butterfly disc shall close against direction of flow.

B. Install ball or butterfly valves for shut-off and isolating service, to isolate equipment, part of systems, or vertical risers.

C. Install globe or angle valves for throttling service and control device for meter by-pass.

D. Provide shut-off valves and check valves on discharge of pumps.

E. Use circuit balancing valves in water systems at all main balancing points and at each coil.

F. Use butterfly valves, in heating water, chilled and condenser water systems for all valves 3" and larger. Use ball valves in heating water, chilled water, and condenser water for all valves 2-1/2" and smaller.

G. All valves shall be located so that the bonnets can be removed.

H. Where valves are installed concealed in pipe chases or above inaccessible ceilings, provide Zurn Z-1460-4 access doors with concealed hinge and key operated locks. Door shall be large enough to service valves and shall be installed flush with finished walls and ceilings.

END OF SECTION 23 05 23

SECTION 23 05 29 - SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Rods.

B. Pipe Hangers and Supports.

C. Duct Hangers and Supports.

D. Flashing for Mechanical Piping, Ductwork and Equipment.

E. Pipe and Duct Penetration Sleeving and Sealing for All Services.

1.2 SUBMITTALS

A. Submit shop drawings on proposed methods and materials including hangers, hanger attachments, wall supports, trapeze supports, floor supports, HVAC unit suspension, submit details of pipe and duct penetrations, sleeves, sealing and UL approved fire stop assemblies.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. B-Line.

B. Grinnell.

C. Unistrut.

2.2 RODS

A. Provide electrogalvanized steel hanger rods, threaded both ends, threaded one end or continuous threaded.

2.3 PIPE HANGERS AND SUPPORTS

A. Hangers: Pipe sizes 1/2 inch to 1-1/2 inch: adjustable Galvanized steel ring, Grinnell #69.

B. Hangers: Pipe sizes 2 inches to 4 inches; adjustable Galvanized steel clevis, Grinnell #260.

C. Hangers for Glass Pipe: Adjustable wrought steel ring with internal padding.

D. Vertical Support for Glass Pipe: Riser clamp lined with 1/4" thick neoprene.

E. Hangers: Pipe sizes 6 inches and over: adjustable Galvanized steel yoke. Provide cast iron roll for all hot piping, Grinnell #181.

F. Multiple or Trapeze Hangers: Galvanized Steel channels with welded spacers and hanger rods, metal slide for pipe sizes 6 inches and over. Provide cast iron roll and stand for Hot Pipe sizes 6 inches and over.

G. Wall Support: Pipe sizes to 3 inches: cast iron hook, Grinnell #67.

H. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp, adjustable steel yoke and metal slide for pipe sizes 6 inches and over. Provide cast iron roll for Pipe sizes 6 inches and over.

I. Vertical Support: Steel riser clamp, Grinnell #261.

J. Floor Support for Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, locknut nipple, floor flange and concrete pier to steel support, Grinnell #264.

K. Steel Beam Clamps: Grinnell #134. Obtain approval from structural engineer to suspend from bottom chord of bar joists.

L. Expansion Anchors: Phillips Red Head.

M. Design hangers to impede disengagement by movement of supported pipe.

N. Provide copper plated hangers and supports, or two layers of PVC tape, where hangers and supports are in direct contact with the copper pipe.

O. "C" type beam clamps are not permitted.

2.4 DUCT HANGERS AND SUPPORTS

A. Comply with SMACNA Standards Section 4.

2.5 FLASHING

A. Steel Flashing: 26 gauge galvanized steel.

B. Lead Flashing: 5 lb./sq. ft. sheet lead for water-proofing, one lb./sq. ft. sheet lead to soundproofing.

C. Safes: 5 lb./sq. ft. sheet lead or 8 mil thick neoprene.

D. Caps: Steel, 22 gauge minimum, 16 gauge at fire resistant structures.

2.6 SLEEVES

A. Provide an opening around all piping passing through walls, floors, roofs, foundations, footings, and grade beams sufficient to allow free movement of piping.

B. Box out openings larger than 8" X 8".

C. Coordinate openings through structural systems with Architect/Engineer.

D. Ends of sleeves shall be flush through walls, and 4" above floors.

E. For exterior and foundation walls and for slabs on grade, use waterproof system with synthetic rubber seals, Link-Seal or approved equal.

F. Sleeves through non-rated construction:

1. Provide Schedule 40 galvanized steel pipe sleeve in concrete walls, mechanical rooms, tunnels, stairwells, and structural systems. Sleeves shall be 0.05" thick galvanized sheet metal.
2. For insulated piping: Provide a 1" annular space between the insulation and sleeve, filled with mineral wool or fiberglass insulation.
3. For non-insulated piping: Provide a 1" annular space between the pipe and sleeve, filled with mineral wool or fiberglass insulation.

G. Sleeves through fire rated and smoke-rated construction:

1. Maintain rating of fire-rated and smoke-rated construction.
2. Provide Schedule 40 galvanized steel pipe sleeve.
3. Insulation shall not pass through construction. Provide a 1" gap between the uninsulated pipe and sleeve. Fill the annular space with UL listed material that maintains fire and/or smoke rating of construction. Refer to Division 07270 specifications for sealers and materials.

PART 3 - EXECUTION

3.1 PIPE HANGERS AND SUPPORTS

A. All structures and appurtenances employed for the purpose of supporting the pipe and guiding it properly shall be carefully fabricated in such a manner as to preserve the true grade of the pipe without subjecting either the pipe or the supporting and guidance members to any undue strain.

B. Support horizontal piping and provide hangers and rods at each change in direction. Spacing shall comply with Manufacturer's Standardization Society (MSS) Standard Practice SP-69. The material used for the piping support shall be designed to allow zero deflection. In cases of conflict between the specifications and this Standard, the most stringent requirements shall govern.

C. Support horizontal soil pipe near each hub, with 5 feet maximum spacing between hangers.

D. Support PVC pipe according to manufacturer's recommendation for the application intended, i.e., Elevated Temperatures.

E. Install hangers to provide minimum 1/2 inch clear space between finished covering and adjacent work.

F. Place a hanger within one foot of each horizontal elbow.

G. Use hangers which are vertically adjustable 1-1/2 inch minimum after piping is erected.

H. Support piping at each change of direction, at ends of branches, at base and top of riser pipes and drops, and wherever necessary to prevent sag, bending or vibration, in addition to above-listed hanger spacing.

I. Support vertical piping at every other floor. Support vertical soil pipe at each floor at hub.

J. Pipe hangers on insulated lines shall be sized to fit the outside of the insulation.

K. Where several pipes can be installed in parallel and at the same elevation, provide multiple or trapeze hangers, designed to support loads per ANSI B31.1.

L. Where practical, support riser piping independently of connected horizontal piping.

3.2 HANGERS AND SUPPORTS FOR DUCTWORK

A. Comply with SMACNA Standards Section 4.

B. Externally insulated ducts shall be supported on full trapeze hangers in accordance with SMACNA Standard 4-5.

3.3 EQUIPMENT BASES AND SUPPORTS

A. Except as otherwise specified or indicated on the drawings, provide for major equipment minimum four inch thick, 6 X 6 - 10/10 mesh reinforced concrete house-keeping bases poured directly on structural floor slab pinned in place and extended 6 inches minimum beyond machinery bedplates. Provide 45 degree by one inch bevel of top surface edge along concrete base. Provide templates, anchor bolts and accessories required for mounting and anchoring equipment. Coordinate with other trades. Construct supports of structural steel members or steel pipe and fittings. Brace and fasten with flanges bolted to structure.

B. Grout all bases of base mounted pumps in solid to concrete pad with non-shrink epoxy grout.

3.4 PRIMING

A. Prime coat non-galvanized or non-plated steel hangers, reinforcements and supports.

3.5 FLASHING

A. Flash and counterflash where mechanical equipment passes through weather or waterproofed walls, floor, and roofs.

B. Flash vent and soil pipes projecting 12 inches minimum above finished roof surface with lead worked 1 inch minimum into hub, 8 inch minimum clear on sides with minimum 24 inch x 24 inch sheet size. For pipes through outside walls, turn flange back into wall and caulk.

C. Flash floor drains over finished areas with lead 10 inch clear on sides with minimum 36 inch x 36 inch sheet size. Fasten flashing to drain clamp device.

D. Provide curbs for mechanical roof installation 12 inch minimum high. Flash and counterflash with steel, soldered and waterproofed.

3.6 SLEEVES

A. Set sleeves in position in advance of concrete work. Provide suitable reinforcing around sleeves.

B. Extend sleeves through floors 2 inches above finished floor. Caulk sleeves full depth.

C. Sleeves through walls shall be flush with the finished wall surface.

D. Size sleeves large enough to allow for movement due to expansion, to allow insulation to extend through the sleeve in non-fire rated walls, floors and partitions uninterrupted and to allow space for proper sealing.

E. Install fire stop assemblies in strict accordance with manufacturer's printed installation instructions and provisions of UL rating.

F. Install chrome plated escutcheons where piping passes through finished surfaces.

G. Pipe and duct sleeves, pitch pockets, and flashings compatible with the roofing installation shall be provided for roof penetrations.

END OF SECTION 23 05 29

SECTION 23 05 48 - MECHANICAL VIBRATION CONTROL

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Vibration Isolators.

B. Flexible Connectors.

C. Sound Attenuating Units.

D. Seismic Restraints.

1.2 SUBMITTALS

A. Submit manufacturer's data for all vibration isolation components including:

1. Dimensional data.
2. Materials.
3. Details of construction.
4. Spring diameter.
5. Spring free height.
6. Maximum load.
7. Rated deflection.

B. For each item of equipment describe the isolation system to be provided including:

1. Bases.
2. Isolators.
3. Flexible connections.
4. Seismic restraints.
5. Loads for each isolator.
6. Disturbing frequency of equipment.
7. Natural frequency of isolators.
8. Static deflection.
9. Isolation system efficiency at operating speed.
10. Seismic restraint calculations.

C. For sound attenuators submit manufacturer's product data including:

1. Dimensional data.
2. Materials of construction.
3. Details of construction.
4. Pressure drop at design air flow.
5. Sound attenuation in each octave band.

1.3 QUALITY ASSURANCE

A. A representative of the vibration isolation manufacturer shall inspect the completed project and testify in

writing all vibration isolation devices and systems are installed according to manufacturer's installation instructions.

B. The vibration isolation manufacturer shall perform calculations required to properly design all seismic restraints.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Isolators and Flexible Connectors:

1. Amber-Booth.
2. Consolidated Kinetics.
3. Keflex.
4. Korfund.
5. Mason Industries.
6. Vibration Mountings and Controls, Inc.
7. Metraflex.
8. Vimco

B. Sound Attenuators:

1. Industrial Acoustics.
2. Commercial Acoustics.
3. Koppers.
4. Rink.
5. Spiral Pipe of Texas.
6. Titus.
7. Transonics.
8. United McGill Corporation.

2.2 VIBRATION ISOLATORS

A. Steel components shall be PVC coated or phosphated and painted with industrial grade enamel.

B. All nuts, bolts and washers shall be zinc-electroplated or cadmium plated.

C. Structural bases shall be thoroughly cleaned of welding slag and primed with zinc-chromate or metal etching primer. A finish coat of industrial enamel shall be applied over the primer.

D. All isolators exposed to the weather shall have steel parts hot-dip galvanized or zinc-electroplated.

E. Isolators shall be capable of 30% over-travel before becoming solid.

F. Where height-saving brackets for side mountings of isolators are required, the height-saving brackets shall be designed to provide for a minimum operating clearance of 1" under the inertia base.

G. Limit the length of the exposed adjustment bolt between the top of the isolator and the underneath side of a bracket or isolation base to 2" maximum.

H. All isolators supporting a given piece of equipment shall be selected for approximately equal spring deflection.

I. Isolators for equipment installed out-of-doors shall be designed to provide adequate restraint due to normal wind conditions and to withstand wind load of 30#/sq. ft. applied to any exposed surface of the equipment without failure.

J. Isolators for equipment which create thrust during operations shall be provided with suitable thrust restraints.

K. Isolators for equipment with different empty and operation weights shall be equipped with restrained mountings.

L. Isolator Type 1:

1. Double deflection neoprene-in-shear type.
2. Static deflection of 0.40 inches.
3. Steel top plate and base plate imbedded in color coded neoprene for rated load capacity identification.
4. Bolt holes in the base plate and tapped holes in the top plate for securing equipment.
5. Neoprene-in-shear mountings similar to Vibration Mountings and Controls Type RD.

M. Isolator Type 2:

1. Free standing steel spring type.
2. 1/4" neoprene pad beneath base plate.
3. Bolt holes in base plate.
4. Adjusting bolts for leveling and equipment attachment.
5. Equal horizontal and vertical spring constants.
6. Vibration Mountings and Controls Series A.

N. Isolator Type 3:

1. Housed steel spring seismic restraining type.
2. Vertical limit stop to prevent spring extension.
3. 1/2" minimum clearance between springs and limit stop housing and around restraining bolts.
4. 1/4" neoprene pad beneath base plate.
5. Bolt holes in base plate.
6. Adjusting bolts for leveling and equipment attachment.
7. Vibration Mountings and Controls Type AEQ.

O. Isolator Type 4:

1. Housed steel spring type.
2. Cast telescoping housing containing one or more steel springs.
3. 1/4" neoprene pad beneath base.
4. Bolt holes in base plate.
5. Adjustment bolts for leveling and equipment attachment.
6. Resilient upper and lower housing guides.
7. Vibration Mountings and Controls Series C or D.

P. Isolator Type 5:

1. Free standing steel spring type.
2. Limit stops to prevent spring extension.
3. Adjusting bolt.
4. Neoprene acoustical non-skip pad bonded to bottom plate.
5. Vibration Mountings and Controls Series AWR.

Q. Isolator Type 6:

1. 1/4" layers of oil resistant neoprene (bottom.)
2. 1/2" layer of cork laminated between neoprene layers.
3. 1/4" layer of oil resistant ribbed neoprene (top.)
4. Vibration Mountings and Controls Cork Rib Pad.

R. Isolator Type 7:

1. Steel spring in combination with neoprene-in-shear type hanger.
2. Minimum total static deflection of 1.25 inches.
3. Steel housing.
4. Vibration Mountings and Controls Series RSH.

S. Isolator Type 8:

1. Steel spring in combination with neoprene-in-shear type hanger.
2. Minimum static deflection of 1.25 inches.
3. Steel housing designed so that equipment or piping can be installed at a fixed elevation regardless of load changes.
4. Adjusting device to transfer load to spring.
5. Vibration mountings and Controls Series RSHP.

T. Isolator Type 9:

1. Double deflection neoprene-in-shear type hanger.
2. Minimum total static deflection of 0.40 inches.
3. Vibration Mountings and Controls Type RHD.

U. Isolator Type 10:

1. Horizontal thrust restraint for air thrusts and starting torques.
2. Cadmium plated steel springs.
3. Galvanized steel hardware for attachment to both the equipment, ductwork and/or structure.
4. Vibration Mountings and Controls Type HTR.

V. Isolator Type 11:

1. Rooftop curb-mounted vibration base.
2. Cadmium plated steel springs.
3. Flexible neoprene seal.
4. Vibration Mountings and Controls Type AXR.

W. Isolator Type 12:

1. Steel channel rails with Type 1.
2. Neoprene-in-shear isolators.
3. Vibration Mountings and Controls Type RB.

2.3 BASES

A. Base Type 1:

1. Constructed of wide flanges with depth equal to a minimum of 1/10 of longest span of equipment.
2. Adjustable motor slide rails integral to base where required.
3. Height saving brackets at all mounting positions.
4. Vibration Mountings and Controls Type WFB.

B. Base Type 2:

1. Independent structural steel rails.
2. Constructed of wide flanges with depth equal to 1/10 of the longest span of the equipment.
3. Height saving brackets at all mounting positions.
4. Vibration Mountings and Controls Type WFR.

C. Base Type 3:

1. Structural steel channel concrete pouring form.
2. Channel depth equal to 1/12 of the longest span of equipment and not less than 6 in.
3. Reinforcing rods 3/8 inches in diameter welded in place 1-1/2" above the bottom of the base and running in both directions 8 inches on center.
4. Steel members welded in place for bolt hole templates.
5. Forms for horizontally split case pumps shall be extended to provide for suction and discharge elbow supports.
6. Height saving brackets shall be located at all mounting positions.
7. Vibration Mountings and Controls Type WPF.

2.4 FLEXIBLE CONNECTIONS

A. Type 1: Flexible connections of a stainless steel seamless corrugated core with stainless steel braided cover. Use threaded or soldered ends for pipe sizes 2 inches and less, Vibration Mountings and Controls Type MFP. Use flanged ends for pipe sizes 3 inches and larger.

B. Type 2: Pump connectors for pipe sizes 12 inches and smaller shall be twin spheric type. Connectors for pipe sizes 14 inches and larger shall be single sphere type fabricated of multiple layers of molded, reinforced neoprene. The connector shall be suitable for operating pressures of 150 psig at 220 degrees F. and 26 in. HG vacuum. Connectors shall have flanged ends and over extension control rods, Vibration Mountings and Controls Series VM.

C. Three flexible type grooved joint couplings may be used in lieu of flexible connectors at equipment connections in applicable piping systems. The couplings shall be placed in close proximity to the vibration source. Basis of Design: Victaulic Company.

2.5 SOUND ATTENUATORS

A. Casing: Minimum 22 gauge galvanized steel or 18 gauge aluminum. Longitudinal seams shall be lock formed and sealed or continuously welded. Casings shall be constructed and reinforced to withstand the system pressures and shall not vibrate audibly during normal operation.

B. Sound Absorbent Material: Long fiberglass acoustical blanket packed to eliminate voids. Material shall be inert, vermin and moisture proof and odorless. Material shall comply with ASTM E-84 and shall have the following maximum fire classification values:

1. Flame Spread 25.
2. Fuel Contributed 20.
3. Smoke Developed 20.

C. Internal Liner: Minimum 26 gauge perforated galvanized steel or 22 gauge perforated aluminum having a minimum free area of 40 percent.

D. Internal Liner: Minimum 26 gauge perforated galvanized steel or 22 gauge perforated aluminum having a minimum free area of 40 percent. An impervious membrane shall be placed between the acoustic fill and the metal inner liner. The liner shall comply with the fire classification ratings of the acoustic fill material and shall comply with the requirements of the applicable Health Regulatory Agency. Attenuator ends shall be capped with plastic during delivery and storage.

2.6 SEISMIC RESTRAINTS

A. Restraints shall permit adjustment during installation to insure sufficient clearance between vibration isolated element and rigid restraining device.

B. Restraining devices at all base supported vibration isolated equipment shall be separate units.

C. Restraints at base supported equipment shall include resilient neoprene pads at all potential contact areas between isolated equipment and rigid restraining element.

D. Restraints shall be capable of withstanding seismic forces in any direction in accordance with the local code and the Uniform Building Code.

E. Restraints at all suspended piping, ductwork and equipment shall be arranged to achieve the required all-directional restraint and sized to resist the seismic forces as required. Shop drawings shall indicate proposed method for achieving vertical restraint for suspended items. Cables shall have sufficient slack to avoid short circuiting the vibration isolators.

PART 3 - EXECUTION

3.1 VIBRATION ISOLATORS

A. Install all vibration isolation devices, sound attenuators, flexible connections and seismic restraints in accordance with the manufacturer's printed installation instructions.

B. Install bases and vibration isolators as scheduled on drawings.

C. Provide Type 2 Spring Isolators to support piping connected to isolated equipment in all mechanical rooms and for a distance of 50 feet from the equipment, whichever is greater. The static deflection of the first three hangers shall be the same as that of the isolated equipment up to a maximum of 2 inches. The remaining hangers shall have a 0.75 inch static deflection.

3.2 FLEXIBLE CONNECTIONS

A. Install in accordance with manufacturer's recommendations.

B. Install Type 1 Flexible Connections in piping to all isolated equipment except pumps.

C. Install Type 2 Flexible Connectors in piping to all pumps.

3.3 SOUND ATTENUATORS

A. Install in accordance with manufacturer's instructions.

B. Multiple modules shall be assembled with a steel frame around the entire bank. Tack weld along the length of adjoining attenuators and apply sealant at both ends of attenuators to prevent air leakage.

3.4 SEISMIC RESTRAINTS

A. Restraints shall not be installed until vibration isolators have all been loaded and adjusted to achieve the specified static deflection and clearances.

B. Where piping and ductwork cross structural separations, provide for proper movement of structural elements without damage to piping, ductwork or their supports.

END OF SECTION 23 05 48

SECTION 23 05 53 - MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe Identification.

B. Valve Identification.

C. Equipment Identification.

1.2 SUBMITTALS

A. Submit product data describing materials and methods of attachment for each type of identification device.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Brady.

B. Seton.

2.2 PIPE IDENTIFICATION

A. Pipe markers shall be suitable for all temperatures anticipated in system down periods as well as operational times.

B. Adhesive markers shall be made of minimum 0.005 inch thick vinyl with a minimum tensile strength of 15 lb./in. Adhesive shall be permanent cold temperature pressure sensitive acrylic. Surface preparation shall be as prescribed by the manufacturer. The adhesive marker shall be used on indoor applications only.

C. All snap over type pipe identification shall be outdoor grade equal to Brady HB-689 or approved equal. Stainless steel straps shall be used on pipe size (including insulation) six inches and over.

D. Paint for pipe identification shall be high grade high gloss enamel in accordance with Section 09900.

E. Each marker shall indicate direction of flow with an arrow pointing away from the marker. When flow can be in each direction the marker shall have double ended arrows.

F. The marker shall comply with ANSI A13.1 and ANSI Z53.1 for Scheme and color codes. The table below may be used as a guide:

Classification	Color of Field	Color of Letter for Legend
	Materials of Inherently Low Hazard	
Liquid or Liquid Admixture	Green	White
Gas or Gaseous Admixture	Blue	White

G. The size of letters and color field shall comply with the following table:

Outside Diameter of Pipe or Covering	Length of Color Field A	Size of Letters B
in.	in.	in.
3/4 to 1-1/4	8	1/2
1-1/2 to 2	8	3/4
2-1/2 to 6	12	1-1/4

H. Letter style shall be bold and easy to read, similar to Sans Serif gothic bold.

2.3 VALVE IDENTIFICATION

A. Valve tags shall have valve number corresponding with the valve schedule.

B. Each valve tag shall be minimum 20 gage polished brass not less than 1-1/2 inches in diameter. Each tag shall identify service (1/4" stamped letters) and valve number (1/2" letters).

C. Tags shall be secured to the valve with approved meter seal, Brass "S" hook, Brass jack chain, or other approved methods.

D. Abbreviations for service shall be as follows with the system designation indicating the system served. (Note: color coded aluminum tags may be used for this purpose in lieu of brass tags).

ABBREVIATIONS

BPRV	Back Pressure Relief Valve Vent Line
HWS	Heating Water Supply
HWR	Heating Water Return
CHS	Chilled Water Supply
CHR	Chilled Water Return
CWS	Condenser Water Supply
CWR	Condenser Water Return

RS	Refrigerant Suction
RL	Refrigerant Liquid
RHG	Freon Hot Gas

2.4 EQUIPMENT IDENTIFICATION

A. Equipment identification tags shall identify the function and use of the equipment in language corresponding to the drawings and schedules.

B. Aluminum nameplates shall be with black enamel background with etched or engraved natural aluminum lettering not less than 3/8" high.

C. Engraved laminated plastic nameplates may be used on indoor equipment with 3/8" high lettering and contrasting letter color.

D. Stenciled high gloss painted lettering in accordance with Section 09900 may be used when applied neatly, with minimum 1 inch high lettering over a contrasting color painted background of suitable size for the lettering.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All identification shall be located so that the view is unobstructed.

B. Attachment of all identification tags or plate shall be permanent, suitable for the location and located so as to not interfere with system operation or maintenance.

C. Equipment manufacturer’s nameplates or identification shall not be obscured.

3.2 PIPE IDENTIFICATION

A. Use a pipe marker at each valve to show proper identification of pipe contents. Where several valves exist on one header, it is necessary to mark only the header.

B. Apply a pipe marker and an arrow marker at every point of pipe entry or exit or where line goes through a wall (both sides).

C. Apply pipe markers and arrow markers at intervals not exceeding 25 feet in both horizontal and vertical runs.

D. Apply markers around circumference of pipe where view is unobstructed in open and service areas above ceiling.

E. Pipe identification markers and arrow flow markers shall be provided on the following piping systems:

1. Chilled Water Supply & Return
2. Heating Water Supply & Return
3. Condenser Water Supply & Return
4. Refrigerant Liquid and Suction.

5. Steam and condensate.
6. Air Conditioning Condensate

F. The legend shall be explicit in identifying the contents. Examples are shown below:

Examples of Legends

High Temp Water 400 Deg. 250 PSI
Air 100 PSI
Foam

3.3 VALVE IDENTIFICATION

A. Identify each valve in a manner that will permit free operation of the valve.

B. Charts of all valves shall be furnished in duplicate by the Contractor, said charts to include the following items:

1. Valve Identification Number.
2. Location.
3. Purpose.
4. Type.
5. Service.
6. Pressure.
7. Class.
8. Manufacturer.
9. Figure number.

C. One chart shall be mounted in an aluminum frame with Plexiglas and secured on a wall in the main machine room.

D. Charts shall be included in each O&M manual.

3.4 EQUIPMENT IDENTIFICATION

A. All pieces of major equipment shall be identified as to function and distinguishing number.

B. Date Labels (Newly Installed Equipment): Below each identifying label described in the paragraph above, provide a second label of the same size and material with the warranty start date, warranty end date, and subcontractor company name as indicated, below.

C. Plates shall be attached with screws, rivets, or adhesive (inside building only).

WARRANTY START DATE:	11-15-2007
WARRANTY END DATE:	11-15-2010
INSTALLED BY:	ZYX MECHANICAL

END OF SECTION 23 05 53

SECTION 23 05 93 - TESTING, ADJUSTING, BALANCING, AND COMMISSIONING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY:

A. This Section includes testing, adjusting, balancing, and commissioning HVAC systems and alarm point reporting verification to produce design objectives, including the following:

1. Balancing airflow and water flow within distribution systems, including sub-mains, branches, and terminals, to indicated quantities according to specified tolerances.
2. Adjusting total HVAC systems to provide indicated quantities.
3. Measuring electrical performance of HVAC equipment.
4. Setting quantitative performance of HVAC equipment.
5. Verifying that automatic control devices are functioning properly and perform their intended functions.
6. Calibrating automatic temperature control sensors.
7. Commissioning the HVAC system.
8. Verification of building alarm and alarm remoting.
9. Reporting results of the activities and procedures specified in this Section.

B. Related Sections include the following:

1. Testing and adjusting requirements unique to particular systems and equipment are included in the Sections that specify those systems and equipment.
2. Field quality control testing to verify that workmanship quality for system and equipment installation is specified in system and equipment Sections.

1.3 DEFINITIONS:

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including sub-mains, branches, and terminals, according to design quantities.

C. System Commissioning: The process for achieving, verifying, and documenting the performance of that system to meet the operational needs of the building within the capabilities of the design and to meet the design documentation and the owner’s functional criteria, including preparation of the operator personnel.

D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

E. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

F. Report Forms: Test data sheets for recording test data in logical order.

G. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

H. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

I. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

J. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

K. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

L. Test: A procedure to determine quantitative performance of a system or equipment.

M. Testing, Adjusting, and Balancing Agent: The entity responsible for performing and reporting the testing, adjusting, balancing, and commissioning procedures.

N. AABC: Associated Air Balance Council.

O. AMCA: Air Movement and Control Association.

P. ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers

Q. CTI: Cooling Tower Institute.

R. NEBB: National Environmental Balancing Bureau.

S. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.

1.4 SUBMITTALS:

A. Contract Documents Examination Report: Within 45 days from the Contractor's Notice to Proceed, submit 8 copies of the Contract Documents review report as specified in Part 3 of this Section.

B. Commissioning Plan: Within 60 days from the Contractor's Notice to Proceed, submit 8 copies of the Commissioning Plan including step-by-step procedures as specified in Part 3 "Preparation" Article below. The Commissioning plan shall include, but not be limited to the following items:

1. TAB field data sheets.
2. Control points verification sheet.
3. Control sequence verification sheet.
4. Alarm points verification sheet.

1.5 QUALITY ASSURANCE:

A. Agent Qualifications: TAB and Commissioning agent shall be an ABC approved agency.

B. Commissioning Conference: Meet with the Owner's and the Engineer's representatives on approval of the Commissioning Plan to develop a mutual understanding of the details. Ensure the participation of testing, adjusting, and balancing team members, equipment manufacturers' authorized service representatives, HVAC controls Installer, and other support personnel. Provide 7 days' advance notice of scheduled meeting time and location.

1. Agenda Items: Include at least the following:

a. Submittal distribution requirements.
b. Contract Documents examination report.
c. Testing, adjusting, and balancing plan.
d. Work schedule.
e. Coordination and cooperation of trades and subcontractors.
f. Coordination of documentation and communication flow.

C. Certification of Testing, Adjusting, and Balancing Reports: Certify the testing, adjusting, and balancing field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified testing, adjusting, and balancing reports.
2. Certify that the testing, adjusting, and balancing team complied with the approved testing, adjusting, and balancing plan and the procedures specified and referenced in this Specification.

D. Testing, Adjusting, and Balancing Reports: Use testing, adjusting, and balancing Agent's standard forms approved by the Engineer.

E. Instrumentation Calibration: Calibrate instruments at least every 6 months or more frequently if required by the instrument manufacturer.

1.6 PROJECT CONDITIONS:

A. Full Owner Occupancy: The Owner will occupy the site and existing building during the entire testing, adjusting, balancing, and commissioning period. Cooperate with the Owner during these operations to minimize conflicts with the Owner's operations.

B. Partial Owner Occupancy: The Owner may occupy completed areas of the building before Substantial Completion. Cooperate with the Owner during testing, adjusting, balancing, and commissioning operations to minimize conflicts with the Owner's operations.

1.7 COORDINATION:

A. Notice: Provide 7 days' advance notice for each test. Include scheduled test dates and times.

B. Perform testing, adjusting, and balancing after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.8 AT&T INSTALLATION GUIDE TP76300 - GENERAL INSTALLATION STANDARDS:

A. AT&T Technical Guide TP76300 must be used as general guidelines for service and installation purposes. The guidelines are necessary to effectively coincide with AT&T personnel, Contractors, and other Suppliers. These guidelines consist of procedures for prior, during, completion of job installation and service. The guide covers method of procedures to properly manage and deal with unforeseen situations that may take place during the installation.

B. Reference the TP76300 Technical Guide and other procedures set forth by AT&T Company for implementing an error free policy when work is performed within AT&T buildings. This manual shall be obtained from your AT&T contact or representative.

PART 2 - PRODUCTS **(Not Applicable)**

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Examine Contract Documents to become familiar with project requirements and to discover conditions in systems' designs that may preclude proper testing, adjusting, balancing, and commissioning of systems and equipment.

1. Contract Documents are defined in the General and Supplementary Conditions of the Contract.
2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine project record documents described in Division 1 Section "Project Record Documents."

D. Examine Engineer's design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data, including fan and pump curves. Relate performance data to project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce the performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Specification Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine air-handling equipment to ensure clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine terminal units, such as variable-air-volume boxes and mixing boxes, to verify that they are accessible and their controls are connected and functioning.

L. Examine plenum ceilings, utilized for supply air, to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

M. Examine strainers for clean screens and proper perforations.

N. Examine 3-way valves for proper installation for their intended function of diverting or mixing fluid flows.

O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

P. Examine open-piping-system pumps to ensure absence of entrained air in the suction piping.

Q. Examine equipment for installation and for properly operating safety interlocks and controls.

R. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices operate by the intended controller.
2. Dampers and valves are in the position indicated by the controller.
3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including 2-way valves and 3-way mixing and diverting valves, are properly connected.
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record set points and calibration method(s).
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to design values.

S. Report deficiencies discovered before and during performance of testing, adjusting, balancing, and commissioning procedures.

3.2 ALARM POINT AND REPORTING VERIFICATION:

A. Participate in and witness a verification of all applicable HVAC system alarms as these systems relate to the energy management system and remote alarm process.

B. All alarm points (verification of set point) and control points shall be verified.

C. Written documentation of the verification process shall be included in the final Test and Balance Report. Date of test, alarm and control set points, verification of alarm remoted to proper AT&T alarm center and comments shall be included.

3.3 GENERAL TESTING AND BALANCING PROCEDURES:

A. Perform testing and balancing procedures on each system according to the procedures contained in this section.

B. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.4 FUNDAMENTAL AIR SYSTEMS' BALANCING PROCEDURES:

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. For variable-air-volume systems, simulate diversity of the system when balancing the system.

C. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

D. Check the airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check dampers for proper position to achieve desired airflow path.

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Check for proper sealing of air-handling unit components.

3.5 CONSTANT-VOLUME AIR SYSTEMS' BALANCING PROCEDURES:

A. The procedures in this Article apply to constant-volume supply-, return-, and exhaust-air systems. These additional procedures are specified in other articles in this Section.

B. Adjust fans to deliver total design airflows within the maximum allowable rpm listed by the fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:

a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
b. Measure static pressure directly at the fan outlet or through the flexible connection.
c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.

1) Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

2. Measure static pressure across each air-handling unit component.

    a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers under final balanced conditions.

4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.

C. Adjust volume dampers for main duct, sub-main ducts, and major branch ducts to design airflows within specified tolerances.

1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.

    a. Where sufficient space in sub-mains and branch ducts is unavailable for Pilot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone

    .

2. Remeasure each sub-main and branch duct after all have been adjusted. Continue to adjust sub-mains and branch ducts to design airflows within specified tolerances.

D. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or the outlet manufacturer's written instructions and calculating factors.

E. Adjust terminal outlets and inlets for each space to design airflows within specified tolerances of design values. Make adjustments using volume dampers rather than extractors and the dampers at the air terminals.

1. Adjust each outlet in the same room or space to within specified tolerances of design quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 FUNDAMENTAL PROCEDURES FOR HYDRONIC SYSTEMS:

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check expansion tank liquid level.
3. Check makeup-water-station pressure gage for adequate pressure for highest vent.

4. Check flow-control valves for specified sequence of operation and set at design flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type, unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.7 HYDRONIC SYSTEMS' BALANCING PROCEDURES:

A. Determine water flow at pumps. Use the following procedures, except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Verify with the pump manufacturer that this will not damage pump. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on the manufacturer's pump curve at zero flow and confirm that the pump has the intended impeller size.
2. Check system resistance. With all valves open, read pressure differential across the pump and mark the pump manufacturer's head-capacity curve. Adjust pump discharge valve until design water flow is achieved.
3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on the pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Report flow rates that are not within plus or minus 5 percent of design.

B. Set calibrated balancing valves, if installed, at calculated presettings.

C. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than design flow.

E. Adjust balancing stations to within specified tolerances of design flow rate as follows:

1. Determine the balancing station with the highest percentage over design flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over design flow and proceeding to the station with the lowest percentage over design flow.
3. Record settings and mark balancing devices.

F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures, including outdoor-air temperature.

G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.8 MOTORS:

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer, model, and serial numbers.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.9 TEMPERATURE-CONTROL VERIFICATION:

A. Verify that each point on the "Points List" exists, is terminated properly, is functioning properly, and is calibrated.

B. Verify that controllers are calibrated and commissioned.

C. Check transmitter and controller locations and note conditions that would adversely affect control functions.

D. Record controller settings and note variances between set points and actual measurements.

E. Verify operation of limiting controllers (i.e., high- and low-temperature controllers).

F. Verify free travel and proper operation of control devices such as damper and valve operators.

G. Verify sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water-flow measurements. Note the speed of response to input changes.

H. Confirm interaction of electrically operated switch transducers.

I. Confirm interaction of interlock and lockout systems.

J. Verify main control supply-air pressure and observe compressor and dryer operations.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.10 TOLERANCES:

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans: Plus 5 to plus 10 percent.
2. Air Outlets and Inlets: 0 to minus 10 percent.
3. Heating-Water Flow Rate: 0 to minus 10 percent.
4. Cooling-Water Flow Rate: 0 to minus 5 percent.

3.11 REPORTING:

A. Construction Progress Reports: As Work progresses to the 75% and 95% complete stages, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested, balanced, and commissioned.

B. Final Commissioning Documents: The General Contractor shall be responsible for the assembly and delivery of the final commissioning documents. The following items shall be included but not limited to this list:

1. Final Test & Balance Report shall be provided by the Test and Balance Agent, including:

a. Test & Balance field data sheets.
b. Control points verification sheets.
c. Control sequence verification sheets.
d. Alarm points verification sheets.

2. Final commissioning plan shall be provided by the Test & Balance Agent, as submitted in submittal phase revised to include any changes necessitated by field changes.
3. Start-up and functional test reports and verification forms shall be provided by the Mechanical Contractor, Controls Contractor, Electrical Contractor and Fuel Oil Contractor.

3.12 FINAL TEST AND BALANCE REPORT

A. Certified Testing, Adjusting, and Balancing Reports: Submit 8 copies of reports prepared, as specified in this Section, on approved forms certified by the testing, adjusting, and balancing Agent.

B. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in 3-ring binder, tabulated and divided into sections by tested and balanced systems.

C. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.

1. Include a list of the instruments used for procedures, along with proof of calibration.

D. Final Report Contents: include the following:

1. Test & Balance field data sheets.
2. Control points verification sheets.
1. Control sequence verification sheets.
2. Alarm points verification sheets.
3. Pump curves.
4. Fan curves.
5. Manufacturers' test data.
6. Field test reports prepared by system and equipment installers.
7. Other information relative to equipment performance, but do not include approved Shop Drawings and Product Data.

E. General Report Data: In addition to the form titles and entries, include the following data in the final report, as applicable:

1. Title page.
2. Name and address of testing, adjusting, and balancing Agent.

3. Project name.
4. Project location.
5. Engineer's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of testing, adjusting, and balancing Agent who certifies the report.
10. Summary of contents, including the following:

    a. Design versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

11. Nomenclature sheets for each item of equipment.
12. Data for terminal units, including manufacturer, type size, and fittings.
13. Notes to explain why certain final data in the body of reports vary from design values.
14. Test conditions for fans and pump performance forms, including the following:

    a. Settings for outside-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings, including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

B. System Diagrams: Present with single-line diagrams and include the following:

1. Quantities of outside, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.

C. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data: Include the following:

    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches, and bore.
    i. Sheave dimensions, center-to-center and amount of adjustments in inches.
    j. Number of belts, make, and size.
    k. Number of filters, type, and size.

2. Motor Data: Include the following:

a. Make and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Sheave dimensions, center-to-center and amount of adjustments in inches.

3. Test Data: Include design and actual values for the following:

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Filter static pressure differential in inches wg.
f. Preheat coil static-pressure differential in inches wg.
g. Cooling coil static-pressure differential in inches wg.
h. Heating coil static-pressure differential in inches wg.
i. Outside airflow in cfm.
j. Return airflow in cfm.
k. Outside-air damper position.
l. Return-air damper position.
m. Vortex damper position.

D. Apparatus-Coil Test Reports: For apparatus coils, include the following:

1. Coil Data: Include the following:
a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch.
f. Make and model number.
g. Face area in sq. ft.
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data: Include design and actual values for the following:

a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outside-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.

n. Refrigerant suction temperature in deg F.
o. Inlet steam pressure in psig.

E. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data: Include the following:

a. System identification.
b. Location.
c. Coil identification.
d. Capacity in Btuh.
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Airflow rate in cfm.
i. Face area in sq. ft.
j. Minimum face velocity in fpm.

2. Test Data: Include design and actual values for the following:

a. Heat output in Btuh.
b. Airflow rate in cfm.
c. Air velocity in fpm.
d. Entering-air temperature in deg F.
e. Leaving-air temperature in deg F.
f. Voltage at each connection.
g. Amperage for each phase.

F. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data: Include the following:

a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Sheave dimensions, center-to-center and amount of adjustments in inches.

2. Motor Data: Include the following:

a. Make and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Sheave dimensions, center-to-center and amount of adjustments in inches.
g. Number of belts, make, and size.

3. Test Data: Include design and actual values for the following:

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

G. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data: Include the following:

a. System and air-handling unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft.
g. Design airflow rate in cfm.
h. Design velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

H. Air-Terminal-Device Reports: For terminal units, include the following:

1. Unit Data: Include the following:

a. System and air-handling unit identification.
b. Location and zone.
c. Test apparatus used.
d. Area served.
e. Air-terminal-device make.
f. Air-terminal-device number from system diagram.
g. Air-terminal-device type and model number.
h. Air-terminal-device size.
i. Air-terminal-device effective area in sq. ft.

2. Test Data: Include design and actual values for the following:

a. Airflow rate in cfm.
b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

I. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data: Include the following:

a. System and air-handling unit identification.

b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data: Include design and actual values for the following:

a. Airflow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

J. Chiller Reports: For each chiller, include the following:

1. Unit Data: Include the following:

a. Unit identification.
b. Make and model number.
c. Manufacturer's serial number.
d. Refrigerant type and capacity in gal.
e. Starter type and size.
f. Starter thermal protection size.

2. Condenser Test Data: Include design and actual values for the following:

a. Refrigerant pressure in psig.
b. Refrigerant temperature in deg F.
c. Entering-water temperature in deg F.
d. Leaving-water temperature in deg F.
e. Entering-water pressure in feet of head or psig.
f. Water pressure differential in feet of head or psig.

3. Evaporator Test Reports: Include design and actual values for the following:

a. Refrigerant pressure in psig.
b. Refrigerant temperature in deg F.
c. Entering-water temperature in deg F.
d. Leaving-water temperature in deg F.
e. Entering-water pressure in feet of head or psig.
f. Water pressure differential in feet of head or psig.

4. Compressor Test Data: Include design and actual values for the following:

a. Make and model number.
b. Manufacturer's serial number.
c. Suction pressure in psig.
d. Suction temperature in deg F.
e. Discharge pressure in psig.
f. Discharge temperature in deg F.
g. Oil pressure in psig.
h. Oil temperature in deg F.

i. Voltage at each connection.
j. Amperage for each phase.
k. The kW input.
l. Crankcase heater kW.
m. Chilled water control set point in deg F.
n. Condenser water control set point in deg F.

K. Pump Test Reports: For pumps, include the following data. Calculate impeller size by plotting the shutoff head on pump curves.

1. Unit Data: Include the following:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model and serial numbers.
f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump rpm.
j. Impeller diameter in inches.
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data: Include design and actual values for the following:

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

L. Cooling Towers:

1. Measure the following data for each cooling tower:

a. Manufacture (Model/Serial No.).
b. G.P.M. (Design/Actual)
c. Entering Water Temperature (Design/Actual)
d. Leaving Water Temperature (Design/Actual)
e. ΔT (Design/Actual)
f. Wet Bulb Temperature (Design/Actual)

g. Motor:

1) Manufacturer
2) Horsepower
3) Phase
4) Voltage
5) Starter Manufacturer
6) Starter Size
7) Heater Size
8) Heater Rating

3.13 ADDITIONAL TESTS:

A. Within 90 days of completing testing, adjusting, balancing, and commissioning, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial testing, adjusting, balancing, and commissioning procedures were not performed during near-peak summer and winter conditions, perform additional inspections, testing, and adjusting during near-peak summer and winter conditions.

END OF SECTION 23 05 93

SECTION 23 07 00 - MECHANICAL INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Piping, Equipment and Duct Insulation.

1.2 SUBMITTALS

A. Submit manufacturer's product data including:

B. Schedule of materials by service showing thickness and finish.

C. Thermal properties.

D. Adhesives and sealants.

E. Installation procedures.

F. Letter of Certification and Guarantee as stated in section 23 07 00, part 1,

1.3 QUALITY ASSURANCE

A. Deliver material to job site in original non-broken factory packaging, labeled with manufacturer's density and thickness.

B. Perform work at temperatures recommended by the product manufacturer.

C. Insulation shall be applied to clean dry surfaces. Piping shall be tested before insulation is applied or joints shall be left uncovered until leak tests have been performed.

D. All insulation shall have composite fire and smoke hazard ratings (insulation, jacket and adhesive used to adhere jacket or facing to the insulation), as tested by procedure ASTM E-84, NFPA 255 and UL 73 not exceeding Flame Spread of 25, Fuel Contributed of 50 and Smoke Developed of 50. All other components such as adhesives, mastics (except joint sealer), cements, tapes and cloths, etc. shall also meet these ratings. ASTM-E84-25/50 rating should be clearly marked on each joint of insulation.

E. All flexible polyolefin and flexible elastomeric insulation shall be guaranteed free from defects in materials and workmanship and insulation and its glue system will not suffer deterioration due to effects of sunlight, moisture penetration, weathering or ozone exposure. Furthermore, insulation manufacturer certifies that insulation and its glue system does not contain any constituents which could potentially cause stress corrosion cracking or pit corrosion, including but not limited to: ammonia, ammonia chloride, ammonium hydroxide, ammonium nitrite, elemental mercury, mercurous nitrate, sulfides, sulfurous compounds, cyanides and hydrogen chloride. If it can be shown that the insulation or its glue system contains any ingredients which cause corrosion, regardless of the environment, the manufacturer will pay for all replacement costs.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Insulation:

1. CertainTeed.
2. Schuller.
3. Knauf.
4. Owens-Corning.
5. Pittsburg Corning.
6. IMCOA (IMCOLOCK, IMCOSHIELD)

B. Adhesives, Sealants and Finishes:

1. Foster.
2. Childers.
3. 3M.
4. Pittsburg Corning.
5. IMCOA-FUSE_SEAL SYSTEM

2.2 MATERIALS

A. Fiberglass Pipe Insulation: 3 pcf density, pre-molded pipe covering with white all service vapor barrier jacket and pressure sensitive adhesive longitudinal lap seal, 0.23 K factor at 75°F. FSK concealed.

B. Fiberglass Board: 6 pcf density exposed and 3 pcf concealed, semi-rigid glass fiber board with white exposed all service vapor barrier jacket, 0.23 K factor at 75° F. FSK concealed.

C. Fiberglass Blanket: 1.0 pcf density, glass fiber blanket with foil scrim Kraft vapor barrier jacket, minimum total R value of 6.0 at 75° F., 0.75 pcf concealed, 1.0 pcf exposed.

D. Polyolefin Insulation: Flexible polyolefin thermal insulation with 0.24 K-factor 75° F. IMCOA-IMCOLOCK and IMCOSHIELD.

PART 3 - EXECUTION

3.1 PREPARATION

A. Do not install covering before ductwork and equipment have been tested and approved.

B. Ensure surface is clean and dry prior to installation.

C. Apply finishes with system at operating conditions.

3.2 INSTALLATION

A. Install all insulation and apply all sealants, IMCOA FUSE_SEAL SYSTEM, and finishes in strict

accordance with manufacturer's printed installation procedures.

B. Insulation shall be continuous through sleeves in wall openings. Pipe insulation penetrating floors and ceilings through sleeved penetrations shall be reduced to ½" thickness.

C. At all pipe hanger locations where the insulation must resist compression and piercing, supporting devices must be used in combination with metal hanger shields. Supporting devices such as cork stoppers, short lengths of wood dowels, wood blocks, or polyolefin dowels which have the same thickness of the insulation may be used. Coat the dowel with an approved adhesive before insertion into the insulation and coat the outer surface to provide a vapor seal. Protect insulation at hangers, guides and rollers with 16 gauge galvanized metal saddles and a section of rigid foamglass insulation a minimum of 12 inches long and 2 circumference of the insulation.

D. Repair separation of joints or cracking of insulation due to thermal movement or poor workmanship.

E. Locate seams in least visible locations.

F. Fiberglass Pipe Insulation:

1. Apply insulation to pipe and seal longitudinal seam with pressure sensitive Foster 85-60 water base adhesive lap. Seal butt joints with vapor barrier adhesive. Finish with vapor barrier adhesive and 4 inch butt strips of facing material. Overlap adjacent pipe 2 inches minimum.
2. Seal ends of pipe insulation at valves, fittings, flanges, etc. and at 21 foot intervals on continuous runs with vapor barrier sealant.
3. Fittings: Apply insulation to the same thickness as the adjoining pipe. Finish with white PVC fitting covers and seal all joints with PVC adhesive and 2 inch PVC tape. Finish shall overlap adjacent insulation by 2 inches minimum.
4. Valves, Strainers and Flanges Cold Service: Provide covers fabricated from insulation of the same thickness as the adjoining pipe. Overlap the adjacent insulation by 4 inches minimum. Pack voids with glass fiber blanket. Apply vapor barrier Foster 85-60 water base adhesive to all butt joints. Fabricate in a minimum of sections to facilitate service and replacement. Finish with white PVC fitting covers and seal all joints with PVC adhesive and 2 inch PVC tape.
5. Valves and Strainers Hot Service: Insulate valves as described above for cold service. Do not insulate unions, flanges and expansion joints. Terminate insulation on a bevel with plastic troweled material.
6. Protect insulation at hangers, guides and rollers with 16 ga. galvanized metal saddles and a section of rigid foamglass insulation a minimum of 12 inches long and 2 circumference of the insulation.
7. Insulate p-traps of floor drains and hub drains receiving condensate from air conditioning units [and kitchen refrigeration equipment].

G. Fiberglass Equipment Insulation:

1. Apply insulation board of the same thickness as the adjoining pipe. Overlap the adjacent insulation by 4 inches minimum. Pack voids with glass fiber blanket. Apply vapor barrier adhesive to all butt joints. Fabricate in a minimum of sections to facilitate service and replacement. Finish with vapor barrier adhesive and 4 inch strips of facing material overlapping all joints 2 inches minimum. Seal all joints with PVC adhesive and PVC tape.

H. Fiberglass Duct Insulation:

1. Concealed ducts shall be insulated with blanket insulation.
2. Exposed ducts in Mechanical Room for air handling unit shall be insulated with board insulation.
3. Apply insulation to duct with ends firmly butted. Compress duct wrap a maximum of 25 percent.
4. Adhere insulation with Foster 85-60 water base adhesive applied in 6 inch wide strips around the duct perimeter 16 inches on center.
5. On ducts 18 inches wide or over, additionally secure with mechanical fasteners 16 inches on center.
6. Overlap the facing on longitudinal seam a minimum of 2 inches and seal with 100 percent coverage of Foster 85-60 water base adhesive. Staple in place with outward clinch staples.
7. Seal all staple and fastener penetrations and any other breaks in the vapor barrier with vapor barrier mastic and 4 inch wide strips of facing material as the adjacent insulation adhered with 100 percent coverage of Foster 30-80 water based adhesive.
8. Provide a section of rigid foamglass insulation a minimum of 12 inches wide at trapeze hangers.
9. Provide blanket insulation on top of air device’s where the ceiling to structure space is not used as a return air plenum.

I. Polyolefin Insulation:

1. Apply pipe insulation as recommended by the manufacturer.
2. When using IMCOLOCK use ImcoSeal Seam Roller along entire length of seam by applying constant pressure to insure a water-tight seam.
3. Seal all joints and seams with IMCOA's FUSE_SEAL system, Foster 30-15 Adhesive, or factory approved equal.
4. Insulation finish shall be suitable for field painting.
5. Apply finishes in accordance with manufacturer's specifications.

3.3 FINISHES

A. Finish piping exposed outdoors, in indoor occupied spaces up to seven feet above floor in mechanical rooms with 0.016 inch thick corrugated aluminum jacketing secured with aluminum bands. Provide pre-molded aluminum fitting covers for fittings, valves, etc. Seal all joints with clear silicone sealant.

B. Finish insulated ductwork and Buffer Tank exposed to view either indoors or outdoors with 0.016 inch thick textured aluminum overlapped and adhered with rivets so as not to penetrate the vapor barrier. Seal all joints with clear silicone sealant. On outdoor ducts, overlap and seal rivets in a manner to shed rainwater and provide a weathertight seal.

3.4 MATERIAL SCHEDULE

A. Piping:

1. Chilled Water. (above ground) - fiberglass
2. Condensate Drain. - polyolefin

B. Equipment:

1. Chilled and Hot Water Pumps. - fiberglass
2. CHW Expansion Tanks. - fiberglass
3. Chilled water Buffer Tank. - fiberglass

C. Ductwork:

1.	Supply Air Ducts. (In Mechanical Room)	- fiberglass board
2.	Outside Air Ducts.	- fiberglass board
3.	Supply Ductwork (above suspended ceiling)	- fiberglass blanket

3.5 INSULATION THICKNESS SCHEDULES

A. Hot and Cold Piping:

INSULATION THICKNESS SCHEDULES
Hot and Cold Piping

	Pipe Size Inches				
Pipe Temperature F	1 or less	1-1/4 to 3	4 to 6	8 to 12	Over 12
40 to 60	1.0	1.5	2.0	2.5	2.5
RS for DX Refrigeration	1.0	1.5	1.5	1.5	--
Piping Exposed to Ambient Temperatures *	2.0	2.5	3.0	3.5	3.5

* DENOTES ALL PIPING OUTSIDE THE INSULATED AND CONDITIONED ENVELOPE OF A BUILDING, IE. CRAWL SPACES, ATTICS, TUNNELS, COVERED WALKWAYS, ETC.

B. Equipment:

Item	Minimum Thickness
Chilled and Hot Water Pumps	1.5 inches
CHW and HW Expansion and Buffer Tanks	1.5 inches
Air Separator	1.5 inches
Chemical Pot Feeder	1.5 inches

C. Ducts:

Service	Minimum Thickness Installed R=6.0 Minimum
Supply Air Ducts	2 inches
Outside Air Ducts	2 inches

END OF SECTION 23 07 00

SECTION 23 09 00 – BUILDING ENERGY MONITORING AND CONTROL SYSTEM

PART 1 - GENERAL INSTALLATION STANDARDS

1.1 RELATED SECTIONS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections apply to this Section and other sections of Division 23 and Division 26, as follows:

B. Division 26, as follows:

1. Section 23 09 93: Sequence of Operation
2. Section 23 05 93: Testing, Adjusting, Balancing and Commissioning
3. Section 26 00 00: General Requirements for Electrical Work
4. Section 26 05 33: Raceway and Boxes for Electrical Systems
5. Section 26 05 19: Low-Voltage Electrical Power Conductors and Cables
6. Section 28 34 13: Leak Delection/Location Systems

1.2 AUTHORIZED INSTALLATION ENTITIES:

A. Qualifications: Building Automation -The Controls Contractor shall be an established supplier of control products and components and have a minimum of 5 years experience in the related field. The Contractor shall have all employees required to prepare the system installation drawings, submittals, acquire the product, install and calibrate the system and components, program, adjust, troubleshoot and repair. The Contractor shall be adequately equipped and staffed to maintain a service organization capable of warranty maintenance, as well as to provide extended service on installed systems upon request and / or as specified hereinafter. The Contractor shall have factory certified personnel. Upon request, the contractor shall provide a list of references with site names and contact numbers for completed projects of similar size.

B. Qualifications: Security – The Security Contractor shall be an established supplier of Security / Access / CCTV products and components, hold a valid security license and have a minimum of 5 years experience in the related field. All employed security personnel shall hold a valid license to install and service the Security / Access products. The Contractor shall have all employees required to prepare the system installation drawings, submittals, acquire the product, install and calibrate the system and components, program, adjust, troubleshoot and repair. The Contractor shall be adequately equipped and staffed to maintain a service organization capable of warranty maintenance, as well as to provide extended service on installed systems upon request and / or as specified hereinafter. Upon request, the contractor shall provide a list of references with site names and contact numbers for completed projects of similar size.

C. Approved Manufacturers and Bidders: Subject to compliance with the specification requirements, provide building automation, control, security and fuel oil monitoring systems as used in area by AT&T or Andover Controls Corporation.

1.3 SCOPE OF WORK:

A. The Contractor shall furnish all controllers, field devices, associated components and full technical services. Layout of the system shall be by this contractor along with all terminations of the controlled components. The combined work shall result in a central computerized Direct Digital Control (DDC) System. All respective input, output, entry / exit door card reader, electric access control, alarmed exit door, cameras, fuel oil monitoring and miscellaneous points shall be connected to DDC controllers located throughout the building. The AT&T provided (OCS group) high speed Local Area Network (LAN) system shall connect to Network Master Control Units (NMCU) to establish data communications within the building and database file server in Bell Plaza Dallas. In absence of LAN the AT&T (RAS Group) shall install hardware required to gain connection to the LAN. To establish data communications with the Local Control Units (LCU's), a secondary LAN shall be provided by this vendor or the installing subcontractor, to operate independently of the primary LAN. Connected points to NMCU's and LCU's outlined in the Input / Output (I/O) Summary plus any points required to meet the sequence of operation shall be provided and installed. Installation shall adhere to guidelines as defined by this Section.

1.4 AT&T INSTALLATION GUIDE TP76300 - GENERAL INSTALLATION STANDARDS:

A. AT&T Technical Guide TP76300 must be used as general guidelines for service and installation purposes. The guidelines are necessary to effectively coincide with AT&T personnel, Contractors, and other Suppliers. These guidelines consist of procedures for prior, during, completion of job installation and service. The guide covers method of procedures to properly manage and deal with unforeseen situations that may take place during the installation.

B. Reference the TP76300 Technical Guide and other procedures set forth by AT&T for implementing an error free policy when work is performed within AT&T buildings. This manual shall be obtained from your AT&T contact or representative.

1.5 GENERAL WIRING AND CABLE INSTALLATION GUIDELINES:

A. Use no less than 3/4" EMT conduit with steel compression fittings. All conduits must be striped with orange tape every 10 feet or manufactured conduit labels, and all j-box covers must be painted orange or marked as “Control System.” All enclosures shall be painted orange.

B. Conduits on entries and foyers shall be roughed into the walls wherever feasible. If surface mounting has to take place then the use of Bell Boxes and rounded edges shall be utilized.

C. Enclosures are provided by Controls Contractor and mounted by the Electrical Contractor.

D. All conduit and wiring methods shall follow all NEC guidelines and division 26 specifications.

E. Workmanship: Provide sufficient supervision, skilled technicians, properly trained and qualified for the work.

F. Electrical work and safety requirements: NFPA 70 and all applicable local and state codes shall be followed. Contractor shall obtain and pay for city permitting and arrange for all required inspections.

G. All electrical wiring between the field devices and controllers are to be brought into the wireway above the enclosure with the exception of power and secondary local area network communications.

H. All wiring brought into the wireway for termination into the enclosure shall be cut no shorter than 6 feet.

I. All wiring shall be marked on each end with a number. A legible list shall be left in the enclosure showing what field device each cable is pulled from or indicated on the working field riser drawings.

J. All enclosure wire terminations are by the Controls Contractor.

K. Power wiring from Inverter or UPS to each enclosure shall be minimum #12 AWG THHN Stranded. Ground wire to each enclosure from UPS must be #10 AWG THHN stranded with green insulation. Solid wire is not acceptable. No power wiring may be run with any input, output or LAN wiring.

L. All LAN cabling shall be per manufacturer's specification with a shield, and have an orange plenum rated jacket. No substitutions may be made for this cable. All LAN wiring shall be run entirely in ¾" EMT from the riser pull box to the enclosure wireway. It is not acceptable for wire, other than Primary or Secondary LAN to be pulled within this conduit.

M. Automation: At a minimum, all automation input cabling between the field devices and the enclosure wireway shall be #22AWG stranded with two (2) conductors with a shield and have an orange plenum rated jacket. All output cabling shall be the same type of a cable except it shall be #18AWG without a shield. Splices are not acceptable.

N. Security: At a minimum, all security input cabling between the field devices and the enclosure wireway shall be #22AWG stranded with two (2) conductors and have an orange plenum rated jacket. All output cabling shall be the same type of cable except it shall be #18AWG. Splices are not acceptable.

O. All penetrations through walls by EMT conduit or cable shall be sleeved and sealed with fire rated sealant (Hilti, 3M or approved equal).

P. The controls contractor shall provide plastic labels for enclosures with 1" high lettering. Labels shall include enclosure number, electrical panel and circuit number of 120 VAC circuits.

Q. Warranty Date Labels: The controls contractor shall provide a label of the same size for each component added to a new or existing panel indicating the component's warranty "Start & End" dates. Label shall read "Warranty START _____, END _____ Dates".

R. Devices shall be tagged with white dot labels indicating controls contractor job number and date of which the device was placed into service. All field devices shall be labeled with "P-touch" label and the drawings shall be provided inside each control panel with clear plastic sleeve.

1.6 CONTROL POWER - INVERTERS / UNINTERRUPTED POWER SUPPLY UPS:

A. Inverters, furnished and installed by controls contractor, shall be used where 48V DC Telco Battery Plant Systems are available to power network controllers (e.g., CX, CMX, etc.), network-routers, security controllers, fuel-oil controllers, and door power. The generator shall power all other devices that are critical control systems.

B. All control panels shall be labeled with the enclosure numbers, electrical power source panel and circuit number of the 120-vac circuit. The control panel label shall designate the floor and the panel number. For example ENC 3-5 would indicate the enclosure was located on the 3PPPrdPPP floor and it was the fifth enclosure on that particular floor. Variable air volume and fan powered boxes shall not have the enclosure labels mentioned above.

C. All projects without UPS circuits or 48V. Telco power plant shall use a stand alone UPS system to power the system.

1.7 GENERAL NOTES:

A. When possible, the HVAC equipment shall be wired fail-safe to prevent system shutdown in the event of a component or Andover Controls system failure.

B. Whenever possible, the security panel and the smoke purge panel shall be located on the first floor near the fire panel (provided by others) or the front door.

C. Provide a separate enclosure for the hub and router adjacent to main control panel.

D. Space temperature, chilled water supply alarms and system failure shall be added for temporary cooling system if not already monitored by existing systems.

1.8 DEMOLITION

A. Each individual job shall have a defined scope by the Contract Documents for that job.

B. Pneumatic Demolition: All thermostats, electric pressure switches and various controlling devices shall be completely removed from service and disposed of. Supply and branch tubing shall be removed completely or to a defined point of demarcation to achieve desired scope. All terminations for tubing to remain shall be cut and capped with compression caps.

C. Electrical Components: All relays, switches sensing devices shall be completely removed from service and disposed of. The Electrical Contractor shall also remove conduits and wiring that is not re-used completely, or to a defined point of demarcation to achieve desired scope.

D. Enclosures: All enclosures shall be removed and disposed unless new scope requires the use of existing wiring or pneumatic branch signal lines wherein the enclosure shall remain in place.

E. Other: If an aforementioned component cannot be removed it shall be labeled as "Abandoned - Not in Service".

1.9 WARRANTY / EXTENDED WARRANTY:

A. Refer to Division 1 for Base Warranty. The project shall be proposed with “one year” extended warranty as a line item. If accepted, Extended Warranty shall start after the expiration of the base 1-year inclusive warranty.

PART 2 - ENGINEERING AND DESIGN

2.1 EQUIPMENT AND MATERIALS:

A. Contractor shall use cataloged products of manufacturer regularly engaged in production and installation of HVAC / Security control products. Products shall be manufacturer's latest standard design, which has been tested and proven in actual use.

B. The specification covers minimum requirements and is not intended to preclude provisions of equipment or methods that exceed the requirements.

C. Supplier shall have the job site staffed with factory-trained technicians fully capable of providing instruction, routine maintenance and emergency maintenance service on all system components.

D. When there is a manufacturer specified device, and/or model number, only that device shall be acceptable. The owner and/or engineer must approve deviations in product prior to submittals.

E. All electric control devices shall be of a type to meet current, voltage, and switching requirement of their particular application.

F. Contractor shall provide properly rated and sized apparatus in the required quantities and locations to operate the DDC system.

2.2 ENVIRONMENTAL CONDITIONS:

A. Controller and I/O equipment shall be designed to operate in ambient temperatures from 32 to 120 degrees F. and relative humidity from 10-95 percent non-condensing.

B. Sensors and Operating Devices: Sensors and devices shall be rated for the environmental conditions in which they operate.

2.3 SYSTEM EXPANSION:

A. The control system shall have the ability to encompass up to 4 million nodes and workstations.

2.4 COORDINATION WITH MECHANICAL CONTRACTOR:

A. Hydronic and flow measuring devices are to be installed by Division 23 mechanical contractor according to manufacturer design installation guidelines.

2.5 SEQUENCE OF OPERATION:

A. Refer to plans for all Sequences of Operation.

2.6 SUBMITTALS / OPERATION AND MAINTENANCE MANUALS:

A. Submittals:

1. Manufacturer's Product Data: Provide Product Data Sheets for the following:

   a. System equipment
   b. Field materials
   c. Network components
   d. Valves
   e. Actuators

2. Drawings: Provide drawing containing the following:

   a. System equipment flow diagrams
   b. System points list with sign-off columns
   c. Sequence of operation- Sequence to be provided by Consulting Engineer in the Construction Documents. Each sequence of operation shall include the BAS and/or the Fuel Oil monitoring alarm conditions.
   d. Power and Communications Riser Diagrams shall be provided. Drawings shall indicate all building automation, security and fuel oil controllers in the building. Drawings shall also include controller location, panel and circuit numbers (provided with as built drawings) and cable routing.
   e. Enclosure layout and wiring details.
   f. Bill of material for all equipment indicating quantity and models numbers.
   g. Provide floor plan indicating information on the location, quantity and type of cable required for each sensor and control point.

B. Operation and Maintenance Manuals:

1. Submit 4 copies of each manual in final form for equipment and systems to the AT&T Project Manager for distribution. Provide separate manuals for each unit of equipment, each operating system, and each electric and electronic system. The utilization of the 4 copies shall be as follows:

   a. For Contractor's file.
   b. For AT&T Design and Construction office files.
   c. For AT&T Property Manager's file.
   d. For the file in the individual AT&T building (handled by AT&T Property Management).

2. Operation and Maintenance manuals shall include the following:

   a. Manufacturer's Product Data: Provide product data sheets for the following:

      1) System equipment
      2) Field materials
      3) Network components
      4) Valves and actuators

3. Drawings: Provide drawing containing the following:

   a. System equipment flow diagrams
   b. System points list with sign-off columns
   c. Sequence of operation
   d. Provide monitoring and/or operating conditions, alarms and alarm routing for each system that is part of the scope of this project.
   e. Power and Communications Riser Diagrams shall be provided. Drawings shall indicate all building automation, security and fuel oil controllers in the building. Drawings shall also include floor plans indicating controller location, panel and circuit numbers and cable routing.
   f. Enclosure layout and wiring details
   g. Bill of material for all equipment indicating quantity and models number

2.7 QUALITY ASSURANCE:

A. Performance Tests: Perform testing, calibration and adjusting of entire system, as documented, on the point's list schedule. Submit written outline upon final turn over to the General Contractor for acceptance.

2.8 SYSTEM STARTUP AND COMMISSIONING:

A. Each point in the system shall be tested for both hardware and software functionality. In addition, each mechanical and electrical system under control of the BAS will be tested against the appropriate sequence of operation specified herein.

B. The BAS contractor shall commission and set in operating condition (after factory start-up) all major equipment and systems being controlled, such as the chilled water and all air handling system that is a part of this scope of work.

C. The BAS Contractor shall provide all manpower and engineering services required to assist the HVAC Contractor and Balancing Contractor in testing, adjusting, and balancing and commissioning of all automation interfaced systems in the building. The BAS Contractor shall have a trained technician available on request during the balancing and commissioning of the systems.

D. Point-to-Point Checkout: Each I/O device (both field mounted as well as those located in FIPs) shall be inspected and verified for proper installation and functionality. A checkout sheet itemizing each device shall be filled out, dated and approved by the TAB for submission to the General Contractor.

E. Controller and Workstation Checkout: A field checkout of all controllers and front end equipment (computers, printers, modems, etc.) shall be conducted to verify proper operation of both hardware and software. A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted to the TAB for submission to the General Contractor.

F. Refer to 23 05 93 of these specifications for the Test and Balance Contractor's scope of work.

2.9 GENERAL TECHNICAL HARDWARE DESCRIPTION:

A. The EMCS shall be a computer based DDC System utilizing high speed (minimum 10 MBPS) Ethernet LAN technology.

B. The EMCS shall consist of the following:

1. Network Master Control Units (NMCU).
2. Stand alone Local Control Units (LCU).

C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, stand-alone DDC panels, and operator devices.

D. Each DDC panel shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection.

E. Provide BAS equipment, which are UL-916 listed and labeled. Comply with FCC rules, Part 15 regarding Class A radiation for computing devices and low power communication equipment operating in commercial environments. Comply with FCC, Part 68 rules for telephone modems and data sets.

2.10 TECHNICAL SPECIFICATION NETWORK MASTER CONTROL UNIT (NMCU):

A. General: Stand-alone NMCU panels shall be microprocessor based, multitasking, multi-user, and real time digital control processors. Each stand-alone NMCU panel shall consist of modular hardware with plug-in enclosed processors, communication controllers and power supplies. A sufficient number of controllers shall be supplied to fully meet the requirements of this specification and the point list on the drawings.

B. Memory: Each new NMCU controller have memory with a minimum of 8 megabyte of Random Access Memory to support its own operating system and support no less than 32 I/O modules and (4) Infinet controllers.

C. Functions:

1. Control processes
2. Energy Management Applications
3. Alarm Management
4. Historical/Trend Data for all points
5. Maintenance Support Applications
6. Custom Processes
7. Operator I/O
8. Dial-Up Communications through external modems
9. Manual Override Monitoring

E. Surge and Transient Protection: Isolation shall be provided at all network terminations to suppress induced voltage transients consistent with IEEE Standard 587-1980.

F. Power Fail Restart: In the event of the loss of inverter power the sites configured with the fail safe standard shall automatically switch over to the secondary emergency, generator or normal power. Non-Volatile memory shall be incorporated for all critical controller configuration data, and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum two (2) hours. Upon restoration of normal power, the NMCU panel shall automatically resume full operation without manual intervention. Should NMCU panel memory be lost for any reason, the user shall have the capability of reloading the NMCU panel via a network workstation.

G. NMCU Software Features:

1. General:

   a. All necessary software to form a complete operating system as described in this specification shall be provided.
   b. The software programs specified in this section shall be provided as an integral part of the NMCU panel and shall not be dependent upon any higher-level computer for execution.

2. Control Software Description: Pre-Tested Control Algorithms: The NMCU panels shall have the ability to perform the following pre-tested control algorithms:

   a. Proportional, Integral plus Derivative Control (PID)
   b. Self Tuning PID
   c. Two Position Control
   d. Digital Filter
   e. Ratio Calculator
   f. Equipment Cycling Protection

3. Mathematical Functions: Each controller shall be capable of performing basic mathematical functions (+, -, *, /), squares, square roots, exponential, logarithms, Boolean logic statements, or combinations of both. The controllers shall be capable of performing complex logical statements including operators such as >, <, =, and, or, exclusive or, etc. These must be able to be used in the same equations with the mathematical operators and nested up to five parentheses deep.

4. Energy Management Applications: NMCU Panels shall have the ability to perform any or all of the following energy management routines:

   a. Time of Day Scheduling
   b. Calendar Based Scheduling
   c. Holiday Scheduling
   d. Temporary Schedule Overrides
   e. Optimal Start
   f. Optimal Stop
   g. Night Setback Control
   h. Temperature Compensated Load Rolling
   i. Fan Speed/CFM Control
   j. Heating/Cooling Interlock
   k. Cold Deck Reset

l. Chilled Water Reset

All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow user customizing.

5. Custom Process Programming Capability: NMCU panels shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

a. Process Inputs and Variables: It shall be possible to use any of the following in a custom process:

1) Any system-measured point data or status
2) Any calculated data
3) Any results from other processes
4) User-Defined Constants
5) Arithmetic functions (+,-,*,/, square root, exp, etc.)
6) Boolean logic operators (and, or, exclusive or, etc.)
7) On-delay/Off-delay/One-shot timers

b. Process Triggers: Custom processes may be triggered based on any combination of the following:

1) Time interval
2) Time of day
3) Date
4) Other processes
5) Time programming
6) Events (e.g., point alarms)

c. Dynamic Data Access: A single process shall be able to incorporate measured or calculated data from any and all other NMCU panels on the local area network. In addition, a single process shall be able to issue commands to points in any and all other NMCU panels on the local area network.

d. Advisory/Message Generation: Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device, buffer the information in a follow-up file, or cause the execution of a dial-up connection to a remote device such as a printer or pager.

6. Run time Totalizing: Stand alone NMCU panels shall be capable of automatically accumulating and storing run time hours for binary input and output points as specified in this specification. The totalizing routine shall have a sampling resolution of one minute or less.

7. The user shall have the ability to define a warning limit for runtime totalizing. Unique, user-specified messages shall be generated when the limit is reached.

8. Analog/Pulse Totalizing: Stand-alone NMCU panels shall be capable of automatically sampling, calculating and storing consumption totals on a user-selected basis.

    a. Totalizing shall provide calculation and storage of accumulations of up to 99,999. units (e.g., KWH, gallons, KBTU, tons. etc.).
    b. The Totalizing routine shall have a sampling resolution of one minute or less.
    c. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

9. Event Totalizing: Stand-alone NMCU panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalizing shall be performed on a user-defined basis.

    a. The event totalizing feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.
    b. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

10. Web server Functionality: All NCMUs on the Ethernet TCP/IP LAN/WAN shall be capable, out-of-the box, to be set up as a web server. The NCMU shall have the ability to store HTML code and “serve” pages to a web browser. This provides the ability for any computing device utilizing a TCP/IP Ethernet connection and capable of running a standard Internet browser (Microsoft Internet Explorer, Netscape Navigator, etc.) to access real-time data from the entire BAS via any NCMUs.

    The WEB server interface shall allow the sharing of data or information between any controller, or process or network interface (ModBus, BACnet, LonTalk and TCP/IP) that the BMS has knowledge of, regardless of where the point is connected on the BAS network or where it is acquired from.

    The NMCU must act directly as the web server. It must directly generate the HTML code to the requesting user (i.e. web browser), eliminating the need for and reliance on any PC-based web server hardware or software except for graphic images. HTML graphic images shall be stored on any shared network PC. The BAS web server shall have the ability to acquire any necessary graphics using standard pathing syntax within the HTML code mounted within the BAS web server. External web server hardware and software are not acceptable, except for graphic images.

2.10 TECHNICAL SPECIFICATION LOCAL CONTROL UNITS (LCU):

A. General: Each Stand alone NMCU Controller shall be able to extend its performance and capacity through the use of remote Local Control Units (LCU's).

B. Each LCU shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each LCU shall be an 8 bit microprocessor-based, multi-tasking, real-time digital control processor.

C. Each LCU shall have sufficient memory to support its own operating system and databases including:

1. Control Processes
2. Energy Management Applications
3. Operator I/O (Portable Service Terminal)
4. 32K minimum of memory (minimum).

D. The operator interface to LCU point data or programs shall be through portable service terminal connected to DDC panels or temperature sensors in the network.

E. Each LCU shall directly support the temporary use of a portable service terminal. The capabilities of the portable service terminal shall include but not be limited to the following:

1. Display temperatures
2. Display status
3. Display set points
4. Display control parameters
5. Override binary output control
6. Override analog set points

F. Power fail Protection: All system set points, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the controller.

G. AHU Local Control Units:

1. The AHU controller can be configured in software to control variable volume air handlers. In addition, points unused in the air handler control scheme can be used in independent control loops, or in supervisory monitoring and control applications by the network.
2. Application Software:

UUUCLASSIFICATIONS OPTIONS

Primary Equipment Types	Mixed air single path
Primary Control Strategies	Room reset of discharge set point
Minimum Outside Air	Separate damper - 2 position Strategies
Preheat Configuration	Electric
Cooling Configuration	Modulated single coil
Fan Start/Stop	Supply fan
Static Pressure Control	Inlet guide vane control
Unoccupied Control	Setup and setback Night cycle,
	Morning warm up and cool down

H. Unitary Local Control Units for Central Plant Equipment:

1. Unitary Controller shall support, but not be limited to, the following types of systems to address:

   a. Chiller
   b. Pumping Systems

2. The Unitary Controller shall support the following point inputs and outputs:

   a. Proportional Analog Outputs
   b. Two Stage Digital Outputs
   c. Pulse Width Modulation Outputs
   d. Analog Inputs
   e. Digital Inputs

3. The Modes of Operation shall be from control modules. Each module receives various analog and digital inputs with individual settings. Control modules may be configured with the following output options:

   a. On/Off
   b. Proportional (P)
   c. Proportional and Integral (PI)
   d. Proportional and Integral and Derivative (PID)

4. Each Unitary Controller shall execute the following mathematical functions:

   a. Average
   b. Minimum/Maximum Select
   c. Line Segment (non-linear input scaling)
   d. Input Selector (multiple analog inputs to single output)
   e. Calculator (up to 8 input variables)
   f. Timer/Pulse
   g. Boolean Logic

2.12 TYPICAL CONTROLLER SELECTIONS:

A. Network Master Control Units (NMCU):

1. CX9680 – shall include at a minimum, 8 meg of RAM, support for 32 I/O modules and support for required Infinet nodes
2. ACX5740 – when access control is required and support for required Infinet nodes.
3. CX models shall be provided at the current revision compatibility and web server enabled.
4. 10Base-T network card
5. X-driver Option (Required for third party interface)
6. External 3Com 56k modem
7. 48vdc to 120vac inverter, Selected according to engineering load calculation
8. If an ISDN router is used to connect the control system to the AT&T WAN, it shall be a CISCO- 804 (provided by AT&T) unless otherwise specified.

9. The CISCO 804 ISDN router shall be located in the separate secured control system enclosure and receive power from an inverter.

B. Local Control Unit (LCU):

1. i2920, i2814, or i2814 per Chiller
2. i2814 per Cooling Tower System

C. Local Control Unit (LCU):

1. i2920, i2814, or i2810 per Air Handler

D. Fan Coil Units and Zone Damper Controller:

1. i2851 per Fan Coil Unit or
2. i2851 per 4 Input / Output Zones

E. Variable Air Volume Box (VAV) or Fan Powered Box (FPB) Controller:

1. i2850, i2866, or i2865 per VAV box or FPB box

F. Miscellaneous Critical Control (Smoke Purge / Power Restart Hydrogen Purge, Refrigerant Purge):

1. i2920, i2814, i2810, or i2850 per individual system

G. Access Control:

1. AC1 per door (Continuum)
2. UI8 per 8 Alarm Inputs (Continuum)
3. ACX5740 (NMCU)

H. Fuel Oil Monitoring:

1. CX9680 shall include at a minimum, 8 meg of RAM, support for 32 I/O modules and support for 4 Infinite nodes.
2. External 3Com 56k modem
3. 250 watt –48vdc to 120vac inverter or UPS as specified by site)

2.13 DC INPUT / OUTPUT DEVICES:

A. Input/output sensors and devices shall be closely matched to the requirements of the DDC controller for accurate, responsive, noise free signal input/output. Control input response shall be high sensitivity and matched to the loop gain requirements for precise and responsive control.

B. All temperature devices shall use precision thermistors accurate to +/- 0.36 degree F over the respective range. Space temperature sensors shall be accurate to +/- 0.36 degrees F over a range of 35 to 140 degrees F. Duct temperature sensors shall be accurate to +/- 0.36 degrees F over a range of –30 to 160 degrees F..

C. Space temperature sensors shall be provided with blank covers. The EMCS shall be capable of communicating with generic sensors. Set point adjustment or override options shall be added when specified.

D. Space humidity sensors shall have an accuracy of 3% at 0 to 90% RH with a temperature operating range of 24 to 132 degrees F.

E. Averaging sensors shall be employed in ducts that are larger than 14 square feet and shall be accurate to +/- 0.36 degrees F over a range of 32 to 160 degrees F. The averaging sensor tube shall contain at least one thermistor every 3 feet, with element lengths of 8, 12.5, and 25 feet. Element length selected shall be based on manufacturers instructions and size of duct being protected..

F. Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Thermal wells shall be brass or stainless steel for non-corrosive fluids below 250 degrees F and 300 series stainless steel for all other applications. Immersion temperature sensors shall be accurate to +/- 0.36 degrees F over a range of 10 to 230 degrees F.

G. Outside air Temperature and Humidity sensors shall be provided with a white aspirated enclosure with 24 VDC circulating fan. Humidity sensor shall have an accuracy of 3% at 0 to 90% RH with a temperature range of 24 to 132 degrees F. Temperature sensor shall be accurate to +/- 0.36 degrees F over a range of –40 to 120 degrees F.

H. Differential and Static Pressure Sensors and Switches:

1. Fan proof-of-flow switches shall be UL listed adjustable current switches or differential pressure switches as specified in the Sequence of Operation or Data Point Summary. For fractional horsepower and non-ducted fans, relays or auxiliary contacts may be used.
2. Pump proof-of-flow switches shall be UL listed adjustable current switches or differential pressure switches as specified in the sequence of operation or data point summary.
3. Airflow and static pressure analog sensors shall be high accuracy suitable for the velocity pressures to be encountered, be selected for approximately 50% over range, and have a 4 to 20 mA, 0-5 volt or 0-10 volt output.

I. Low Temperature Protection Thermostats: Shall be the manual reset type and shall have sensing elements not less than 20' in length. The thermostat shall respond to the coldest one-foot length of the sensing element regardless of the temperature at other parts of the element. The element shall be properly supported to cover the entire duct or coil width. Multiple switches shall be utilized when an area exceeds the coverage limit of one device.

J. Power Monitoring: Measurement of 3-phase power shall be accomplished with a KW/KWH transducer. This device shall utilize direct current transformer inputs to calculate the instantaneous value (kW) and a pulsed output proportional to the energy usage (KWH). Provide Veris Model 6000 Power Transducer or approved equal.

K. Electric/Pneumatic Solenoid Valves: Electric solenoid operated pneumatic valves (EP's) shall have a three-port operation: common, normally open, and normally closed. They shall be rated for 50 psig when used for 25 psig or less applications, or rated for 150 psig when used for 100

psig or less applications. The coils shall be equipped with transient suppression devices to limit transients to 150 percent of the rated coil voltage.

L. Electric to pneumatic transducers: shall operate from either a PWM or analog signal. E/P transducers shall be rated for 0 - 20 PSI operation and accurate to 2% of full scale. E/P transducers shall have a maximum air consumption of 100 SCIM.E/P transducers may be installed at the end device (damper or valve), or mounted separately in a field interface panel, or as part of the controller. All transducers shall be calibrated.

2.14 AUTOMATIC VALVE BODIES:

A. Control-valve patterns and characterization shall be:

1. All valves shall close against the flow direction, and 3-way bodies shall be piped to obtain the indicated normal or fail-safe position. All control valves shall be of globe type with the exception of terminal units.

B. All valves shall be factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated. Up to two inch sized bodies shall be screwed connections. Bodies larger than two-inches shall have flanged connections.

C. Minimum trim requirements are stainless-steel stems with a balance of bronze or brass. This is used unless the application is steam or high close off pressure. Then, the seat shall be of stainless steel.

D. All two-way valves shall be 100% tight shut-off employing composition discs. Leakage through closed ports on 3-way bodies employing metal-to-metal seating shall not exceed 1% of design flow rate.

E. Range ability on electric valves (2-way modulating pattern) for bodies with Cv factors ranging from zero to 4 shall be at least ten times the respective valve's Cv. Otherwise, bodies with Cv greater than 4 shall have a minimum range ability of 25 to 1. All terminal unit valves shall be ball valves with electric actuators. All electric actuators shall fail last position.

F. Flow coefficients (Cv factors) for modulating chilled water valves shall be selected only as large as necessary to pass design flow rate at a maximum 5-psi differential.

G. Butterfly valve bodies shall contain shaft bearing supports on each shaft extremity with leak proof replaceable packing. Valves shall be class 150 ductile-iron body, cadmium plated ductile iron disc, full threaded lug bodies, type 410 stainless steel stem. Bottom half of disc shall close against direction of flow. Zero clearance swing-through disc construction shall be utilized.

H. All two-position valves shall be line sized, with electric actuation of sufficient torque to exceed close off. All electric actuators to come with factory installed limit switches or position feedback for status indication.

2.15 AUTOMATIC DAMPERS:

A. All control damper and actuators shall be provided and installed by the controls contractor.

2.16 VALVE AND DAMPER ACTUATORS:

A. Valve actuators, electric, shall be motor operated from an analog 0-10V DC, 4-20 ma or PWM (pulse width modulation) control signal. Actuators shall be properly sized to provide sufficient torque to position the valve throughout its operating range.

B. Damper actuators (electric) shall be operated from an analog 0-10V DC, 4-20 ma signal, or a 3 wire open-off-close signal. All damper actuators for dampers used at air handling units shall be controlled from the analog signal. Two position and VAV box actuators may be 3 wire open-off-close. Damper actuators shall be properly sized to (80% maximum) provide sufficient torque to position the damper throughout its operating range.

C. All isolation valves and cooling tower bypass valves shall be line size with hand wheels and indicators. Provide end switches for all motorized isolation valves.

D. All dampers in exterior walls (e.g., outside air dampers, relief air dampers, etc.) shall have spring return actuators. When the outside air damper is controlled with the return air damper, the return air damper shall also have a spring return actuator.

2.17 SAFETY CIRCUITS:

A. All safety circuits (fire alarm, freeze protection, high and low static pressure, etc.) shall be hard wired and perform their control safety functions independent of the DDC/EMCS.

B. All air handling equipment with outside air cooling capability shall have low temperature cutouts.

C. Safeties wired to the DDC/EMCS shall be wired to open upon alarm.

2.18 MISCELLANEOUS DETAILS - ADDITIONAL COMPONENTS:

A. The installation of the EMCS shall incorporate all additional components as required to make a complete and functional system. These components shall include, but not be limited to the following: relays, sensors, transducers, surge protectors, controllers, electrical line filters.

PART 3 - COMMUNICATIONS

3.1 DESCRIPTION:

A. The design of the EMCS shall network operator workstations and Network Master Control Unit (NMCU) Panels. Inherent in the system's design shall be the ability to expand or modify the network either via AT&T LAN/WAN only. Auto-dial telephone line modem connections shall allow RAS capability taking over control of a defined operator workstation.

3.2 LOCAL AREA NETWORK:

A. NMCU Panel Support: DDC panels shall directly reside on a local area network such that communications may be executed directly between controllers, directly between workstation, and between controllers on a peer-to-peer basis.

B. Dynamic Data Access: All operator workstations, either network resident or connected via dial-up modems, shall have the ability to access all point status and application report data, or execute

control functions for any and all other devices via the local area network. Access to data shall be based upon logical identification of building equipment.

C. Access to system data by users other than operator workstations shall be accessed via AT&T WAN Intranet. This access shall be granted and viewed by utilizing the WEBSERVER method through Internet explorer. Set-point modifications shall be allowed to those who possess assigned operator user accounts and passwords.

3.3 GENERAL NETWORK DESIGN:

A. Network design shall include the following provisions:

1. High-speed data transfer rates for alarm reporting, quick report generation from multiple controllers and upload/download efficiency between network devices. The minimum baud rate shall be 10mbps Ethernet.
2. Support of any combination of controllers and operator workstations directly connected to the local area network.
3. Failure detection and accommodation of single or multiple failures of workstations, DDC panels or the network media: The network shall include provisions for automatically reconfiguring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures. Any of the aforementioned shall be alarmed at the critical level.
4. Message and alarm buffering to prevent information from being lost.
5. Monitor error detection, correction, and retransmission to guarantee data integrity.
6. Commonly available, multiple-source, networking components and Ethernet TCP/IP protocol shall be used. This Network shall be configured to allow UDP, TCP, HTTP, and UTTP traffic between NMCU and Workstations.

B. Synchronization of the real-time clocks in all DDC panels shall be provided.

3.4 AT&T STANDARD CONNECTIVITY:

A. The Andover system shall connect to the AT&T WAN to deliver alarms as they occur. The AT&T system operators shall be able to distribute access card modifications to the local sites as needed. One or more of the following ways shall connect the system to the Network:

1. The NMCU shall be connected to the AT&T WAN at the local site if there is a network available at the building. AT&T shall issue two (2) IP addresses per site to Controls Contractor to address the NMCU for use directly on the AT&T WAN. UUUThis is the preferred method.

3.5 NMCU CONNECTIVITY: (2 methods)

A. The NMCU controller shall be connected to the AT&T WAN by a dual channel ISDN line if there is not a network available at the building but there is an ISDN hub router in the area. AT&T shall issue an IP address to the controls contractor to address the NMCU for use through the ISDN routers to gain access to the AT&T WAN.

B. NMCU shall be connected to the AT&T WAN by a SWTN line if there is not a network available at the building and there is not an ISDN hub router in the area. In this case, the NMCU controller

shall dial back into a workstation to deliver alarms and update access events. Personnel records shall be loaded to the remote site across the telephone line if a WAN or ISDN connection is not available. Note: In either instance, a SWTN line shall also be connected to the NMCU modem for redundant communication to the system in the event of network or ISDN outage.

PART 4 - OPERATORUUU WORK STATION / FILE SERVER TECHNICAL SPECIFICATION

4.1 GENERAL:

A. The BAS workstation software shall be configured as a multi-workstation system where the database is located on a central file server. The client software on multi-workstation system shall access the file server database program via an Ethernet TCP/IP network running at either 10MBPS or 100MBPS.

B. All Workstations shall be based on personal computers operating under the AT&T approved Microsoft operating system. The application software shall be capable of communication to all Network Control Units and Stand-alone Digital Control Units, feature high-resolution color graphics, alarming, reporting, and is user configured for all data collection and data presentation functions.

C. For multi-workstation systems, a minimum of 64 workstations shall be allowed on the Ethernet network along with the central file server. In this client/server configuration, any changes or additions made from one workstation shall automatically appear on all other workstations without the requirement for manual copying of files. Multi-workstation systems with no central database shall not be acceptable. Multi-workstation systems with distributed/tiered file servers and a central (master) database shall be acceptable.

4.2 WORKSTATION REQUIREMENTS: (Refer to the manufactures published hardware requirements)

4.3 FILE SERVER HARDWARE REQUIREMENTS: (Refer to the manufactures published hardware requirements)

4.4 MODEMS:

A. Provide system compatible 56k modem if required.

4.5 PRINTER:

A. Provide an alarm printer and a separate report/graphics printer. The alarm printer shall be an Epson dot matrix or equivalent and the report printer shall be a HP LaserJet.

4.6 WORKSTATION SOFTWARE:

A. General Description:

1. The software architecture must be object-oriented in design, a true 32-bit application suite utilizing Microsoft OLE, COM, DCOM and ODBC technologies. These technologies make it easy to fully utilize the power of the operating system to share, among applications (and therefore to the users of those applications), the wealth of data available from the NMCU.

The workstation functions shall include monitoring and programming of all DDC controllers. Monitoring consists of alarming, reporting, graphic displays, long-term data storage, automatic data collection, and operator-initiated control actions such as schedule and set point adjustments.

2. Programming of controllers shall be capable of being done either off-line or on-line from any operator workstation. All information shall be available in graphic or text displays.

4.7 SYSTEM DATABASE:

A. The files server database engine must be Microsoft SQL Server, or another ODBC-compliant, relational database program. This ODBC (Open Database Connectivity)-compliant database engine allows for an owner to utilize "their" choice of database and due to its "open" architecture, allows an owner to write custom applications and/or reports which communicate directly with the database avoiding data transfer routines to update other applications. The system database shall contain all point configurations and programs in each of the controllers that have been assigned to the network. In addition, the database shall contain all workstation files including color graphic, alarm reports, text reports, historical data logs, schedules, and polling records.

4.8 INTERFACE:

A. The BAS workstation software shall allow the creation of a custom, browser-style interface linked to the user that has logged into the workstation software.

B. This interface shall support the creation of "hot-spots" that the user may link to view/edit any object in the system or run any object editor or configuration tool contained in the software.

C. Furthermore, this interface must be able to be configured to become a user’s "PC Desktop" – with all the links that a user needs to run other applications. This, along with the Windows NT user security capabilities, shall enable a system administrator to setup workstation accounts that not only limit the capabilities of the user within the BAS software but may also limit what a user can do on the PC and/or LAN/WAN. This might be used to ensure, for example, that the user of an alarm monitoring workstation is unable to shutdown the active alarm viewer and/or unable to load software onto the PC.

4.9 SECURITY:

A. The software shall be designed so that each user of the software can have a unique user name and password. This user name/password combination shall be linked to a set of capabilities within the software, set by and edited only by, a system administrator. The sets of capabilities shall range from View Only, Acknowledge Alarms, Enable/disable and Change Values, Program, and Administer. The system shall allow the above capabilities to be applied independently to each and every class of object in the system. The system must allow a minimum of 256 users to be configured per workstation. There shall be an inactivity timer adjustable in software that automatically logs off the current operator after the timer has expired.

4.10 CONFIGURATION INTERFACE:

A. The workstation software shall use a familiar Windows Explorer -style interface for an operator or programmer to view and/or edit any object (controller, point, alarm, report, schedule, etc.) in the entire system. In addition, this interface shall present a "network map" of all controllers and

their associated points, programs, graphics, alarms, and reports in an easy to understand structure. All object names shall be alphanumeric and use Windows long filename conventions. Object names shall not be required to be unique throughout the system. This allows consistency in point naming. For example, each VAV controller can have an input called “Space Temperature” and a set point called “CFM Set point”. The VAV controller name shall be unique such as VAV for LAB101. Systems requiring unique object names throughout the system shall not be acceptable.

B. The configuration interface shall also include support for template objects. These template objects shall be used as building blocks for the creation of the BAS database.

4.11 COLOR GRAPHIC DISPLAYS:

A. The system shall allow for the creation of user defined, color graphic displays for the viewing of mechanical and electrical systems, or building schematics. These graphics shall contain point information from the database including any attributes associated with the point (engineering units, etc.). In addition operators shall be able to command equipment or change set points from a graphic through the use of the mouse. Requirements of the color graphic subsystem include:

1. Standard Resolution and colors shall be as follows:

a. Continuum Workstations: 1024 x 768 32 bit color

B. SVGA, bit-mapped displays. The user shall have the ability to import Auto CAD generated picture files as background displays.

C. A built-in library of animated objects such as dampers, fans, pumps, buttons, knobs, gauges, ad graphs which can be "dropped" on a graphic through the use of a software configuration "wizard". These objects shall enable operators to interact with the graphic displays in a manner that mimics their mechanical equivalents found on field installed control panels. Using the mouse, operators shall be able to adjust set points, start or stop equipment, modify PID loop parameters, or change schedules.

D. Status changes or alarm conditions must be able to be highlighted by objects changing screen location, size, color and text, blinking or changing from one display to another.

E. Graphic panel objects shall be able to be configured with multiple "tabbed" pages allowing an operator to quickly view individual graphics of equipment, which make up a subsystem or system.

F. Ability to link graphic displays through user-defined objects, alarm testing, or the result of a mathematical expression. Operators must be able to change from one graphic to another by selecting an object with a mouse - no menus shall be required.

4.12 CARD ACCESS GRAPHICAL DISPLAY: (Card Access Menu Standards for Andover Workstations)

A. Overview: A graphic driven menu system will be in place for all AT&T security sites. The graphics will consist of, at a minimum, State Map, LATA Map, Site Location Map, and Site Floor Plans.

B. State Map: The state map will have the LATA Boundaries that will be linked to individual LATA areas. If the state does not have LATA Boundaries, the LATA Map will not be included and the State Map will have general locations of sites with links to the Site Location Map.

C. LATA Map: The LATA Maps will have the general locations numbered. The numbered locations will correspond with a list of sites to the right of the LATA Map. This list will have the building names along with the number corresponding to the LATA Map.

D. Site Location: The Site Location Map will have a Detailed map with at least one major highway displayed on the map. Standard buttons include: Floor Plans, Event View, Event Log, Card Search, Name Search, Social Security Search, Area listings, Personnel, Reports.

1. Floor Plans – A button will open a link to the Floor Plans.
2. Event View – A button will open a link to the Live Events site. Every swipe will be displayed when the Event View is open.
3. Event Log – A button will open a pre-defined list view and show all valid and invalid swipes. This list view will prompt the user for a start date and an end date.
4. Card Search – A button will open a pre-defined list view that prompts the user for a card number. This will return the personnel record with the prompted card number.
5. Name Search – A button will open a pre-defined list view that prompts the user for a last name. This will return the personnel record with the prompted last name. This will also have a wild card feature. For example, if the user enters “Po*”, the list view will return all people with the last name starting with “Po”.
6. Social Security Search – A button will open a pre-defined list view that prompts the user to enter the market code and social security number. For example, if the person’s market were in Texas, the user would enter “BP11111111”. This will return the personnel record with the prompted social security number. This button will also have the wild card feature previously discussed.
7. Area listing – A button will open a pre-defined list view of all areas.
8. Personnel – A button will open a pre-defined list view of all personnel.
9. Reports – A button will start Continuum Reports. The reports are used to view Access Events, Area lists\Personnel list, Alarm Events, and Activity Events.

E. Site Floor Plans: The Site Floor Plans will display the door locations. The door number will be displayed along with the status of the door. The doors will be displayed as rectangles in the proper location. A red rectangle represents a locked door and a green rectangle represents an unlocked door. The door name will be displayed adjacently in yellow. The reader number will be displayed on the rectangle. The reader number will correspond to the reader number in the field. If the user’s cursor is displayed over the door, a description will pop up displaying the area and the door name. If the user clicks on the door it will show a smaller panel displaying the Door Locked Status, Door Switch Status, Exit Request Status, Last Valid Card, Last Invalid Card, and a button for overriding the door. This button will override the door for 5 seconds and will log the date of override for each door. A report will be created for each door to view the last 200 overrides times. This will be use to troubleshoot the site for invalid swipes. All the buttons on the Site Location will be included on the Floor Plans.

4.13 GRAPHICS INTERFACE:

A. General Provisions – The graphics interface standard presented herein represents a typical interface package. Additional graphical elements may be added beyond the scope of what is

contained depending upon unique site conditions and situations. Although the content of the graphic interface varies among sites, the coloration, style, format and hierarchy of the information remains constant.

B. Links Page - A central navigation link page is provided, from which the user can select among buildings / sites by region, city or building name and navigate to the appropriate site *Home Page*.

C. Home Page - The *Home Page* for each building contains a tabular display of all controlled systems (HVAC, security, etc.), summarized such that each column represents an individual floor of the building and all systems either serving or physically located on a particular floor are contained within that column. The field containing the system name serves as a link to the details of that system (*System Pages*). Navigation links are also provided on the *Home Page* to direct the user back to the central navigation *Links Page* to access additional sites. A navigation link to a general *Utilities Page* is proved. Current date, time and site-specific outdoor air conditions are also displayed on the *Home Page*.

D. System Pages - The *System Page* for each controlled system, whether HVAC, security or other, provides textural information for all points monitored and controlled for the particular system, as well as any software points such as setpoints, deadbands, hi/low limits, etc. Each *System Page* contains, at a minimum, navigation links to direct the user back to the central navigation *Links Page* and the site *Home Page*. Each *System Page* also contains a link to *Setpoint Pages* and *Override Pages* to provide user intervention in system operation.

E. Setpoint Page(s) – The *Setpoint Page* for each site provides the user with information about the current setpoints for controlled systems and allows alteration of setpoints (within controlled parameters) to change system operation. Larger sites that require more setpoint parameters than can suitably be displayed on a single graphic page have multiple *Setpoint Pages*, distinguished by floor. Setpoint modifications are processed by comparison of the altered values against allowable ranges. Setpoints are accepted only if the modified value is within an allowable range. Setpoint changes that fall outside of the allowable range generate an error message, providing the system user with information as to why the attempt has failed. To access the *Setpoints Page(s)* the user must log in to the secured portion of the site graphics using an authorized user name and password.

F. Utilities Page – This graphic page displays general site information that does not pertain to only one controlled system. Such items include, but are not limited to, fire alarm, fire trouble, sump pump alarms, commercial/emergency power status, transfer switch status, generator status and inverter information. The *Utilities Page* contains, at a minimum, navigation links to direct the user back to the central navigation *Links Page* and the site *Home Page*.

4.14 AUTOMATIC MONITORING:

A. The software shall allow for the automatic collection of data and reports from any controller through either a hard wire, modem or network communication link. The frequency of data collection shall be completely user-configurable.

4.15 ALARM MANAGEMENT:

A. The software shall be capable of accepting alarms directly from controllers, or generating alarms based on evaluation of data in controllers and comparing to limits or conditional equations

configured through the software. Any alarm (regardless of its origination) shall be integrated into the overall alarm management system and shall appear in all standard alarm reports, be available for operator acknowledgment, and have the option for displaying graphics, or reports.

B. Alarm management features shall include:

1. A minimum of 255-alarm notification levels. Each notification level shall establish a unique set of parameters for controlling alarm display, acknowledgment, keyboard annunciation, alarm printout and record keeping.
2. Automatic logging in the database of the alarm message, point name, point value, connected controller, time stamp, user name and time of acknowledgment, user name and time of alarm silence (soft acknowledgment)
3. Automatic printing of the alarm information or alarm report to an alarm printer or report printer.
4. Playing an audible beep or audio (wave) files on alarm initiation or return to normal.
5. Sending an e-mail or alphanumeric page to anyone listed in a workstation's e-mail account address list on either the initial occurrence of an alarm and/or if the alarm is repeated because an operator has not acknowledged the alarm within a user-configurable time frame. The ability to utilize e-mail and alphanumeric paging of alarms shall be a standard feature of the software integrated with the operating system's mail application interface (MAPI). No special software interfaces shall be required.
6. Individual alarms shall be able to be re-routed to a workstation or workstations at user-specified times and dates. For example, a critical high temperature alarm can be configured to be routed to a Facilities Dept. workstation during normal working hours (7am-6pm, Monday-Friday) and to a Central Alarming workstation at all other times.
7. An active alarm viewer shall be included which can be customized for each user or user type to hide or display any alarm attributes.
8. The font type and color, and background color for each alarm notification level as seen in the active alarm viewer shall be customized to allow easy identification of certain alarm types or alarm states.
9. The active alarm viewer can be configured such that an operator must type in text in an alarm entry and/or pick from a drop-down list of user actions for certain alarms. This ensures accountability (audit trail) for the response to critical alarms.

4.16 CUSTOM REPORT GENERATION:

A. The software shall contain a built-in custom report generator, featuring word processing tools for the creation of custom reports. These custom reports shall be able to be set up to automatically run or be generated on demand. Each workstation shall be able to associate reports with any word processing or spreadsheet program loaded on the machine. When the report is displayed, it shall automatically spawn the associated report editor such as MS Word, Word Perfect, Note Pad, or Lotus 123.

B. Reports can be of any length and contain any point attributes from any controller on the network.

C. The report generator shall have access to the user programming language in order to perform mathematical calculations inside the body of the report, control the display output of the report, or prompt the user for additional information needed by the report.

D. It shall be possible to run other executable programs whenever a report is initiated.

E. Report Generator activity can be tied to the alarm management system, so that any of the configured reports can be displayed in response to an alarm condition.

F. Standard reports shall include:

1. Points in each controller.
2. Points in alarm
3. Disabled points
4. Overridden points
5. Operator activity report
6. Alarm history log.
7. Program listing by controller with status.
8. Network status of each controller

4.17 SPREADSHEET-STYLE REPORTS:

A. The software shall allow the simple configuration of row/column (spreadsheet-style) reports on any class of object in the system. These reports shall be user-configurable and shall be able to extract live (controller) data and/or data from the database. The user shall be able to set up each report to display in any text font, color and background color. In addition the report shall be able to be configured to filter data, sort data and highlight data that meets user-defined criteria.

4.18 HTML REPORTING:

A. The above spreadsheet-style reports shall be able to be run to an HTML template file. This feature shall create an HTML "results" file in the directory of the HTML template. This directory can be shared with other computer users, which shall allow those users with access to the directory to "point" their web browser at the file and view the report.

4.19 SCHEDULING:

A. It shall be possible to configure and down load from the workstation schedules for any of the controllers on the network.

B. Time of day schedules shall be in a calendar style and shall be programmable for a minimum of one year in advance. Each standard day of the week and user-defined day types shall be able to be associated with a color so that when the schedule is viewed it is very easy, at-a-glance, to determine the schedule for a particular day even from the yearly view. To change the schedule for a particular day, a user shall simply click on the day and then click on the day type.

C. Each schedule shall appear on the screen viewable as the entire year, monthly, week and day. A simple mouse click shall allow switching between views. It shall also be possible to scroll from one month to the next and view or alter any of the schedule times.

D. Schedules shall be assigned to specific controllers and stored in their local RAM memory. Any changes made at the workstation shall be automatically updated to the corresponding schedule in the controller.

4.20 PROGRAMMER'S ENVIRONMENT:

A. The programmer's environment shall include access to a superset of the same programming language supported in the controllers. Here the programmer shall be able to configure application software off-line (if desired) for custom program development, write global control programs, system reports, wide area networking data collection routines, and custom alarm management software. On the same screen as the program editor, the programming environment shall include docked debug and watch bars for program debugging and viewing updated values and point attributes during programming. In addition a wizard tool shall be available for loading programs from a library file in the program editor.

4.21 SAVING/RELOADING: (Continuum Revision 1.5 or later):

A. The workstation software shall have an application to save and restore field controller memory files. This application shall not be limited to saving and reloading an entire controller – it must also be able to save/reload individual objects in the controller. This allows off-line debugging of control programs, for example, and then reloading of just the modified information.

4.22 DATA LOGGING:

A. The workstation software shall have the capability to easily configure groups of data points with trend logs and display the trend log data. A group of data points shall be created by drag-and-drop method of the points into a folder. The trend log data shall be displayed through a simply menu selection. This data shall be able to be saved to file and/or printed.

4.23 AUDIT TRAIL:

A. The workstation software shall automatically log and time stamp every operation that a user performs at a workstation, from logging on and off a workstation to changing a point value, modifying a program, enabling/disabling an object, viewing a graphic display, running a report, modifying a schedule, etc.

4.24 FAULT TOLERANT FILE SERVER OPERATION:

A. The system shall provide the option to provide fault tolerant operation in the event of the loss of the CPU, disk drives, or other hardware required maintaining the operational integrity of the system. Operational integrity includes all user interfaces, monitoring of alarm points and access points, and executing access control functions.

B. The switch over mechanism provided shall be automatic. Should the failure be caused by hardware, the system shall immediately switch to the Backup computer. Should the system failure be caused by software (instruction or data), the system shall not pass the faulted code to the Backup computer, otherwise the Backup shall fail in the same manner of the Primary computer.

C. Switch over to the Backup computer shall be initiated and effective (complete) in a manner and time frame that precludes the loss of event data, and shall be transparent to the system users, except for an advisory alarm message indicating that the switch over has occurred.

D. When the system fails-over from the Primary to the Backup computer, no alarm or other event shall be lost, and the Backup computer shall take control of all system functions.

E. A single component failure in the system shall not cause the entire system to fail. All system users shall be informed of any detectable component failure via an alarm event. System users shall not be logged off as a result of a system failure or switch over.

F. The Primary computer shall provide continual indication that the Backup computer is unavailable until such time that the fault has been purged.

END OF SECTION 23 09 00

SECTION 23 21 13.13 - PREINSULATED CHILLED WATER PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Factory prefabricated (preinsulated) chilled water piping for underground service.

1.2 QUALITY ASSURANCE

A. Design Working Pressure: 125 psig.

B. Manufacturers Training Service: The Contractor shall obtain the services of a trained representative of the pipe system manufacturer to instruct contractor's work force in installation procedures for all preinsulated, prefabricated systems.

C. On-Site Supervision of Underground Piping Installation:

1. Provide services of a factory trained representative of the pipe manufacturer for a minimum of four hours, to include preinstallation, installation and testing periods.
2. Representative's daily written reports: Present the original of each report on the day it is prepared and forward a copy to the manufacturer's main office. The report shall be signed by the manufacturer's representative. The report shall state whether or not the condition and quality of the materials used and the installation of the system is in accordance with the plans, specifications, and published standards of the manufacturer, and is satisfactory in all respects. If anything connected with the installation is unsatisfactory, the report shall state that corrective action has been taken or shall contain the manufacturer's recommendations for corrective action. The report shall cover any condition that could result in an unsatisfactory installation. The representative shall take prompt action to return to the factory all damaged and defective material, and shall order prompt replacement of such material.

1.3 SUBMITTALS

A. Manufacturer's Literature and Data:

1. Pipe supports.
2. Valves, gauges and other accessory materials.
3. Factory preinsulated piping components and installation instructions.
4. Pipe fittings and mechanical couplings if used.
5. Anchors and thrust blocking.

B. Manufacturer's certificates for underground piping:

1. That the field representative for the factory insulated pipe installation is technically qualified and experienced in installation of the manufacturer's system and is qualified to provide the required site reports.

C. Upon completion of the work and before final acceptance, the Contractor shall deliver a notarized statement, signed by a principal officer of both the manufacturing firm and the contracting firm, stating that the installation is satisfactory and in accordance with the plans, specifications, and manufacturer's standards.

D. Calculations for thrust blocking for underground piping.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Insul_Pipe.

B. Thermacor Process Inc.

C. Thermal Pipe Systems

2.2 FACTORY PREFABRICATED (PREINSULATED) PIPING

A. Inner Carrier Pipe:

1. Ductile Iron Pipe: Class 50, gasket type mechanical joints, with cement liner.
2. Schedule 40 Steel Pipe: Welded joints.

B. Outer Casing: Outer casing shall be polyvinylchloride or polyethylene as specified below.

1. Polyvinyl chloride (PVC) shall be made of clean, virgin, NSF approved (based on Standard No. 14) Class 12454-B PVC compound conforming to ASTM D1785 and ASTM D1784, Type 1, Grade 1, with thickness as follows:

Casing Diameter	Minimum Thickness
6 inches and smaller	60 mils
8 inches	80 mils
10 inches	100 mils
12 inches	120 mils
14 inches	140 mils
18 inches	180 mils
24 inches	240 mils

2. Polyethylene (PE): Shall conform to ASTM D 1248, Type III, Class C, Category 3 or 4, Grade P 34 with thickness as follows:

Casing Diameter	Minimum Thickness
8 inches and smaller	75
9 inches to 20 inches	150
21 inches to 22 inches	165
23 inches to 24 inches	200

C. Factory Applied Insulation:

1. Foam insulation for prefabricated insulated pipe and fittings shall be polyurethane foam having a density not less than 2 pcf.

a. The polyurethane foam shall completely fill the annular space between the carrier pipe and the casing.
b. Polyurethane foam shall conform to ASTM 591 Type II, formed for conduit, density not less

than 2 pounds per cubic foot.

c. The insulation "k" factor shall not exceed the numerical value of 0.17 Btu/inch/square foot/degree F./hour at 75 degrees mean temperature in accordance with ASTM C177.

2. Insulation thickness for carrier pipe three inches nominal diameter and smaller: Not less than 0.70 inch or the standard manufactured thickness exceeding 0.70 inch.
3. Insulation thickness for carrier pipe larger than three inches nominal diameter: Two inches nominal, but not less than 1-1/2 inches.
4. Manufacturer shall certify that the insulated pipe is free of insulation voids and describe quality control procedure to ensure this can be met.

D. Field Applied Insulation:

1. Insulation for valves, fittings, field casing closures, if required, and other piping system accessories shall be polyurethane matching the pipe insulation. PVC and polyethylene fitting covers may be premolded, precut or job fabricated to fit and shall be removable and reusable. Thickness shall match adjacent piping.
2. Buried fittings and accessories (piping, flanges, elbows, etc.) shall be factory fabricated and may have field foamed polyurethane insulation to match adjacent piping and shall be protected with a covering matching the pipe casing. Shrink sleeves shall be provided over casing connection joints.

E. End Seals:

1. General: Each preinsulated section of piping shall have a complete sealing of the insulation to provide a permanent water and vapor seal at each end of the preinsulated section of piping. Preinsulated sections of piping modified in the field shall be provided with an end seal which is equivalent to the end seals furnished with the preinsulated section of piping.
2. Provide complete sealing of the insulation at each end of each preinsulated conduit section by one of the following methods:

a. Carrying the other casing over tapered pipe insulation ends and extending it to the carrier pipe. Provide sufficient surface bonding area between the casing and the carrier pipe to ensure a permanent water and vapor-resistant seal.
b. Using specially designed prefabricated caps made of the same material and not less than the same thickness as the casing. Provide sufficient surface bonding area between the cap, and both the casing and carrier pipe, to ensure permanent water and vapor-resistant seal.
c. Using rubber ring gaskets designed and dimensioned to fit in the annular space between the casing and carrier pipe in such a manner as to ensure a permanent water and vapor-resistant seal.
d. Using shrink sleeves that shall be either heat shrinkable high temperature rubber, or polyethylene material that can be bound to the carrier pipes and casing to ensure a permanent water and vapor-resistant seal.

F. Casing and end seal testing and certification:

1. Testing and certification procedures by an independent testing laboratory shall demonstrate that casings and end seals are capable of resisting penetration of water into the casing and insulation at twenty feet of head pressure, measured above the highest point of the test sample, subjected over the entire surface of an eight foot test sample of prefabricated pipe for not less than forty-eight hours. Test shall use seventy-five degree F. water for chilled water service, while the sample is either buried or encased in dry bedding sand with a minimum of twelve inches of sand all around sample. The carrier pipe size in the test section shall be three inches in diameter and

shall be restrained during the test period. The insulation thickness shall not exceed the maximum thickness provided for the piping in the project.

2. Test results for Federal Agency Committee on Underground Heat Distribution System or similar results may be substituted.

G. Joints:

1. Push-on joints: Gasketed joints shall be made of styrene butadiene rubber.

H. Pipe Fittings: All pipe fittings shall be ductile iron, short body, class 350, mechanical joint type. All flanges shall be flat faced. Ductile threaded flanges shall conform to ANSI B16.1, 125 pound.

I. Thrust Blocking:

1. Thrust Blocks shall be installed as recommended by the pipe system manufacturer. Thrust blocks may not be required on all systems, and the need for thrust blocks shall be as recommended by the system manufacturer. Thrust blocks, if necessary, shall be installed at all changes in direction, changes in size, valves and terminal ends, such as plugs, caps and tees. Thrust blocks shall be concrete having a compressive strength of not less than 2000 psi after twenty-eighty days. Thrust blocks shall be placed between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, the base and the thrust bearing sides of the thrust blocks shall be poured directly against undisturbed earth. The sides of the thrust blocks not subject to thrust may be poured against forms. Thrust blocks shall be placed so that the joints for all fittings will be accessible for repair wherever possible. No pipe joint shall be imbedded in concrete unless the assembly has previously been hydrostatically tested. The thrust blocks shall provide for transfer of thrusts and reactions without exceeding the allowable stress of the concrete and shall be installed in accordance with pipe manufacturer's instructions. In muck or peat, all thrusts shall be resisted by piles or tie rods to solid foundations or by removal of peat or muck and replaced with ballast of sufficient stability to resist thrusts.
2. The area of backing required for reaction backing of both supply and return piping shall be calculated in accordance with Tables 1 and 2. The safe soil bearing load shall be determined for each site. Calculations covering these determinations shall be submitted for approval prior to placing any reaction backing on the job.

Table 1: Thrust (Two Pipes), 225 psig, Class 150 Pipe

Pipe Size	90 Degree Tees	45 Degree Bends	22-1/2 Degree Bends	11 Degree Bends
3-inch	5,670	8,050	4,360	2,180
4-inch	6,820	11,750	6,390	3,240
6-inch	7,050	24,200	3,200	6,620
8-inch	9,500	41,800	2,600	11,480
10-inch	48,250	68,500	37,000	18,750
12-inch	68,750	97,500	52,750	26,700
14-inch	93,400	32,000	71,700	36,000
16-inch	115,000	171,000	92,600	46,950
18-inch	153,000	217,500	19,000	60,400
20-inch	192,000	270,000	146,500	74,200

Table 2: Safe Soil Bearing Loads, psf

Soil	psf
Soft clay	1,.000
Sand	2,000
Sand and gravel	3,000
Sand and gravel in clay matrix	4,000
Hard shale	10,000

2.3 SLEEVES

A. Provide sleeves wherever the distribution system passes through concrete or masonry walls. Sleeves shall not be installed in structural members, except where indicated or approved. Sleeves shall be steel or cast iron with integral flanges where pipes pass through waterproofing membranes. Prefabricated piping system shall be continuous through the sleeve. Clearance between sleeves and the passing piping or outer casing shall be approximately 1/4-inch all around. Flashing materials and design shall be in accordance with the manufacturer's standards and shall be submitted for approval prior to installation.

2.4 ANCHORS

A. Anchor design shall be in accordance with the published data of the manufacturer and for prefabricated systems shall be factory fabricated by the system manufacturer. In all cases, the design shall be such that water penetration, condensation, or vapor transmission will not wet the insulation

2.5 VACUUM AND AIR RELIEF VALVES

A. Vacuum and air relief valves shall be provided at all piping entry and exit points at the building to automatically release air from the lines when the lines are being filled with water and admit air into the lines when water is being withdrawn in excess of the inflow.

B. Valves shall be iron body with bronze trim and stainless steel floats. Run vent and drain lines from valves to outside of building.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Handling and Storage: Handle and store conduits, pipes and all accessories to ensure complete installation in a sound undamaged condition. Unloading, stacking, moving and storing of materials shall be in strict accordance with the manufacturer's requirements. Take special care to ensure that materials which have exceeded their specified shelf life are not used in the installation of the system. Before installation all materials shall be inspected for defects. Materials found to be defective before or after installation shall be repaired or replaced with sound material, with no additional expense.

B. Installation of Piping Systems: Piping system furnished shall be installed in accordance with the piping system manufacturer's instructions. Piping shall be installed without springing or forcing other than what has been calculated for thermal expansion and contraction. Pipe ends shall have burrs removed by reaming and shall be installed to permit free expansion and contraction without damage to joints or hangers. Nonmetallic pipe cut in the field shall be machined to fit couplings or joints and shall be coated or treated to match standard factory coated ends. Connections between different types of pipe and accessories shall be made with transition fittings approved by the manufacturer of the piping system.

1. Pitching of horizontal piping: Horizontal piping shall be pitched at a grade of not less than one inch in forty feet toward drain point.

C. Cutting of Prefabricated Conduit Sections: Prefabricated conduit sections shall be cut in strict accordance with the manufacturer's recommendations and standards. The cut section shall be treated as required to result in the cut section being identical in every respect to a standard conduit section produced at the factory.

D. Field Casing Closures: Field insulation and encasement of joints shall be accomplished after the visual and pressure tests specified are completed. Field insulation and encasement shall be in accordance with the manufacturer's written instructions. Thickness dimensions of the insulation and casing materials shall not be less than those of the adjoining prefabricated section. Insulating material may be foamed in place polyurethane or premolded polyurethane foam sections. Care should be taken to ensure that field closures are made under conditions of temperature and cleanliness required to produce a sound, continuous vapor barrier. A standard polyethylene heat shrink sleeve shall be installed over the casing and shall have a six-inch minimum overlap at each end.

E. Insulation and Encasement of Pipe Accessories: Flanges, couplings, unions, valves, fittings and other pipe accessories, unless otherwise shown or approved, shall be insulated with removable factory premolded, prefabricated or field fabricated insulation. For accessories buried underground, the casing material and thickness shall be identical to that of the adjoining casing material and thickness shall be identical to that of the adjoining casing. Except accessories buried underground, the casing material and thickness shall be identical to that of the adjoining casing.

F. Trenching and Backfilling: Trench bottoms for underground prefabricated conduit systems shall be smooth and free of sharp objects, stones and debris that could puncture the casing. Where this is a problem, the trench should be over excavated and stabilized by using sand, fine dirt, or similar material. Partial backfilling is required immediately after installation of the pipe. Selected backfill shall be tamped in not more than six inch layers under and around the conduit to a height of not less than six inches above the top of the casing. During this process, joints shall be left exposed for visual inspection during field tests.

G. Open Ends: Open ends of pipe lines and equipment shall be properly capped or plugged during installation to keep dirt and other foreign matter out of the system.

H. Vapor Barrier: Install materials to provide and preserve the integrity of the vapor barrier.

3.2 CLEANING AND TESTING

A. Cleaning of Piping: Prior to the hydrostatic and operating tests, clean the interior of the chilled water distribution system of all foreign materials by thorough flushing.

B. First Hydrostatic Test and Pressure Cycling:

1. All underground chilled water distribution piping shall be tested hydrostatically before backfilling and with the joints of the water carrier pipe exposed. Piping systems with concrete thrust blocks shall not be hydrostatically tested until at least five days after the thrust blocks have been installed.
2. Each cycle shall consist of a ten minute period at 150 psig followed by a five minute period at a pressure less than fifty psig. The next cycle shall begin immediately following the completion of the previous cycle. Pressure rise and drop shall not exceed 100 psi per minute. The pressure gauge shall be located and the pressure measured at the opposite end of the system from where

the pressure is applied. After completion of the hydrostatic pressure cycling the first hydrostatic pressure test may be performed.

C. Final Hydrostatic Test: After successful completion of the hydraulic cycling test, the system shall be pressurized to 1-1/2 times the working pressure up to 150 psig. This pressure shall be held for a minimum of four hours. The method of pressurizing the system shall be disconnected from the system prior to the start of the four hour pressure holding period. If the pressure cannot be held for the specified length of time, the cause of the pressure loss shall be determined, corrected, and all of the tests repeated.

D. Repair joints, replace damaged or porous pipe and fittings and repeat the test without additional cost until the system can be demonstrated to have no leakage.

END OF SECTION 23 21 13.13

SECTION 23 21 16 - HYDRONIC PIPING AND SPECIALTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Chilled and Heating Hot Water Piping.

B. Condenser Water Piping.

C. Condensate Piping.

D. Strainers and Suction Diffusers.

E. Thermometers and Gauges.

F. Air Separators.

G. Expansion Tanks.

1.2 SUBMITTALS

A. Pipe and Pipe Fittings: Manufacturer's data showing materials, ASTM designation, dimensions and schedule.

B. Refer to Section 23 05 00 for Shop Drawing requirements.

C. Strainers: Manufacturer's product data showing dimensions and materials.

D. Suction Diffusers: Manufacturer's product data showing dimensions and materials.

E. Thermometers and Gauges: Manufacturer's product data showing dimensions, materials, scale ranges.

F. Air Separators: Manufacturer's product data showing dimensions, materials, capacity and pressure drop.

G. Expansion Tanks: Manufacturers' product data showing dimensions, tapping sizes and locations, materials, tank volume and acceptance volume.

H. Welder Qualification: Submit welder qualification test records.

I. Submit welding procedures for review prior to starting work.

J. Grooved joint products shall be shown on drawings and product submittals and shall be specifically identified with the applicable style or series number.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Suction Diffusers and Air Separators:

1. AMTROL.
2. Bell & Gossett.
3. TACO.
4. Victaulic (Suction Diffuser).

B. Thermometers and Gauges:

1. Trerice.
2. Weiss.
3. Weksler.

C. Pressure Reducing Valves:

1. AMTROL.
2. Bell & Gossett.
3. TACO.
4. Watts

2.2 PIPE AND PIPE FITTINGS

A. Refer to 22 11 17 for general materials and methods.

B. Chilled, Hot, and Condenser Water: Standard weight, black steel pipe plain end with 150 LB malleable iron threaded fittings or standard weight welding fittings or grooved steel pipe and grooved fittings.

1. Grooved end fittings shall be ductile iron to ASTM A536, Grade 65-45-12; wrought steel to ASTM A234, Grade WPB; or factory-fabricated from ASTM A53 steel pipe. Basis of Design: Victaulic Company.
2. Grooved joint couplings shall consist of two ductile iron housing segments, pressure responsive elastomer gasket, and ASTM A449 zinc-electroplated steel bolts and nuts.
   a. Rigid: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1 and B31.9. Installation-Ready, for direct stab installation without field disassembly. Basis of Design: Victaulic Style 107N.
   b. Flexible: Use in locations where vibration attenuation and stress relief are required. Flexible couplings may be used in lieu of flexible connectors at equipment connections. Three couplings, for each connector, shall be placed in close proximity to the vibration source. Basis of Design: Victaulic Style 177 Installation-Ready, and Style 77.
   c. AGS series two-segment couplings with lead-in chamfer on housing key and wide-width FlushSeal gasket. Basis of Design: Victaulic Style W07 (rigid) and Style W77 (flexible).

C. Condensate Drain Piping: Standard weight, galvanized steel pipe with 150 LB galvanized malleable iron fittings.

2.3 VALVES

A. Valves shall be in accordance with 23 05 23.

2.4 SEDIMENT STRAINERS

A. Strainers shall be Y-Pattern line size with threaded, flanged or grooved ends. An arrow shall be cast on the side of the strainer to indicate the direction of flow. The basket shall be made of stainless steel or monel.

B. Strainers shall have a Class 125 cast iron body with a removable cover and a sediment screen. Cover shall have threaded 3/4" blow-off port.

C. Provide strainers as follows:

Pipe Size	Manufacturer's Model
Up to 2"	20 mesh Stainless Steel
2-1/2", 3"	.045 or .062 perforation
4" thru 16"	.125 perforation

D. Basis of Design: Victaulic Style 732 and W732.

2.5 SUCTION DIFFUSERS

A. Cast ductile iron angle type body with stainless steel inlet vanes rated to 300 PSIG at 230 degrees F. Body shall be ported and threaded for bottom blowoff and gauge connections at diffuser inlet and pump suction.

B. Flanged or grooved inlets shall be connecting pipe size. Flanged outlet shall be pump suction size.

C. Bronze or stainless steel fine mesh start-up strainer. Stainless steel permanent strainer.

D. Adjustable support foot or integrally cast base support boss.

E. Basis of Design: Victaulic 731/W731 Series.

2.6 AIR VENTS

A. Manual air vents shall be 3/4" screwed pattern valves suitable for 150 PSIG maximum working pressure.

2.7 EXPANSION TANKS

A. Diaphragm, captive air type expansion tanks shall be of the size indicated on the drawings and shall have the following features:

1. ASME construction black steel pressure vessel.
2. Corrosion resistant finish.
3. Heavy rubber diaphragm to provide air and water separation.
4. Complete with all required tappings and lifting rings.
5. Provide with saddles or stand as required by the installation.
6. Designed and tested for 125 PSIG working pressure.

2.8 AIR SEPARATORS

A. Provide full line size, tangential air separators as shown on the drawings with the following features:

1. Constructed in accordance with ASME Code.
2. ASME stamped for 150 PSIG design pressure.
3. Complete with all required tappings for air relief and blowdown.
4. Removable stainless steel strainer with 3/16 inch perforations having a minimum free area of five times the cross sectional area of the connecting pipe.
5. Flanged or threaded connection depending on pipe size.

2.9 PRESSURE REDUCING VALVE (MAKE-UP WATER)

A. Provide a pressure reducing valve on the make-up water line to all closed loop chilled and hot water system as follows:

1. Bronze construction.
2. Built in strainer.
3. Brass trim.
4. Adjustable over an 8 PSIG to 25 PSIG range.

2.10 PRESSURE RELIEF VALVE

A. Provide a pressure relief valve on all closed loop chilled and hot water system as follows:

1. ASME stamped.
2. Cast iron body with bronze trim.
3. Set to relieve at 30 PSIG unless higher pressure required due to operating pressures involved.

2.11 THERMOMETERS AND THERMOMETER WELLS

A. Provide 9 inch, aluminum case, brass stem, adjustable angle, non-mercury reading type thermometers where shown on the drawings.

B. Provide brass separable sockets of the correct length for the pipe size in which they are installed, with extension necks when installed in insulated piping.

C. Ranges shall be 0 degrees F to 100 degrees F for chilled water and 30 degrees F to 130 degrees F for condenser water.

D. Brass industrial test wells, 3/4" N.P.T., with cap and chain. Test wells shall be the correct length for the pipe size in which they are installed.

2.12 PRESSURE GAUGES

A. Provide 4-1/2" dial, bourdon type pressure gauges where shown on the drawings.

B. Case shall be cast aluminum with black finish, or stainless steel.

C. Gauges shall have adjustable pointer and bronze movement with 1 percent accuracy over middle half of scale range and 1-1/2 percent accuracy over the balance of the range.

D. Gauges shall have brass socket and be provided with brass pressure snubbers and gauge cock.

E. Ranges shall be 0 to 150 PSI and feet of head (dual scale).

2.13 TEMPERATURE AND PRESSURE PROBE

A. Provide 1/2" solid brass fitting with Nordel valve cores suitable for 275 degrees F and 500 PSI.

B. Fitting length shall be suitable for insulated piping where applicable.

C. Furnish to the owner a temperature and pressure test kit in a protective case containing the following:

1. Pressure gauges: 0-100 PSI; 0-230 ft. wg.
2. Dial thermometers: 25-125 F; 0-220 F
3. Gauge adapters

PART 3 - EXECUTION

3.1 PIPING

A. Grade piping to facilitate drainage.

B. Install piping with careful regard to expansion.

C. Install steel piping in accordance with 22 11 17.

D. Contractor shall obtain welding permit from Owner prior to start of work. When welding inside building, portable smoke eater with HEPA filter shall be used.

E. If grooved piping is used, the contractor shall provide a minimum of one hour of proper training and supervision of the staff during the fabrication and installation of the piping system to ensure best practices in grooved product installation are being followed. The grooved piping and fitting manufacturer will be required to visit the site on regular intervals to assure proper installation. At completion of the project, Contractor shall submit a letter from the manufacturer with signatures of all parties indicating compliance with manufacturer's installation procedures.

3.2 TESTING

A. Test piping systems prior to the application of insulation.

B. For piping installed in concealed spaces or buried, test piping before system is concealed or back filled.

C. Test water piping to a hydrostatic pressure of 125 PSIG for a continuous period of not less than eight hours. During this time carefully inspect the system for leaks. If necessary, repair leaks and test again until no leakage is detected.

D. After testing, and whenever conditions permit, operate systems at normal operating pressure and temperature for not less than five consecutive days. The piping systems must remain free from leaks during this period.

E. Test using higher pressures if required by authorities having jurisdiction.

3.3 SEDIMENT STRAINERS

A. Each drip trap assembly, each control valve and each pressure reducing valve assembly regardless of its size shall be preceded by a sediment strainer. The arrangement of these sediment strainers shall be such that the screens may be removed for cleaning.

B. Sediment strainers shall be installed in piping systems wherever shown on the drawings and at such other points as may be required for the removal of foreign material from the piping system.

C. All strainers shall be provided with full size blowdown ball valve with nipple and cap.

3.4 AIR VENTS

A. Install manual air vents at all high points in the chilled and hot water systems with overflows piped to the nearest drain.

3.5 EXPANSION TANKS

A. Support tanks securely from building structural members with structural steel angles and rods. If tanks rest on floor, secure in place with bolts to the floor. Provide saddles and support legs if necessary.

3.6 AIR SEPARATOR

A. Support air separator from the building structure so that the piping system does not bear the full weight of the separator.

B. Provide blowdown ball valve and pipe to drain.

3.7 PRESSURE RELIEF VALVE

A. Pipe relief to drain.

3.8 THERMOMETERS AND THERMOMETER WELLS

A. Install thermometers with scales upright and in a location where they may be easily read.

B. Install thermometer wells where shown and where required to test and adjust the system.

C. Replace any damaged thermometers. Do not repair.

D. Provide stainless steel wells in steam lines.

3.9 PRESSURE GAUGES

A. Provide coil syphons for gauges installed on steam lines.

B. Provide ball valves or plug cocks at all gauges suitable for the pressures and service involved.

C. Replace any damaged gauges. Do not repair.

END OF SECTION 23 21 16

SECTION 23 21 23 - CENTRIFUGAL PUMPS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Horizontal Split-Case Pumps.

B. End Suction Pumps.

C. In-Line Pumps.

1.2 SUBMITTALS

A. Submit manufacturer's product data showing dimensions and materials of construction.

B. Submit performance curves showing impeller diameter, efficiency, horsepower, net positive suction head and with the operating point clearly marked.

1.3 QUALITY ASSURANCE

A. Pumps shall be constructed in accordance with Hydraulic Institute Standards.

B. Each pump furnished under these specifications shall be Hydrostatic tested up to 175 psi at the factory.

C. When the pumps are shipped from the factory, the manufacturer shall transmit three copies of a certified letter stating the pumps have been dynamically balanced and tested. No pump shall be installed until its test data has been reviewed.

1.4 PAINTING

A. Pump and pump base shall be factory coated with minimum two coats of factory standard paint. Color to be factory standard.

1.5 WARRANTY

A. Provide a warranty on all materials and labor for a period of one year starting from the date of final acceptance.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. PACO.

B. Peerless.

C. Bell and Gossett.

D. ITT.

E. TACO.

F. Weinman.

2.2 HORIZONTAL SPLIT CASE PUMPS

A. Casing:

1. The casing shall be ASTM A48 cast iron of the horizontal split case design. The casing shall have tapped and plugged holes for priming, vent and drain. Removal of the upper half of the casing must allow removal of the rotating element without disconnecting the suction or discharge piping.
2. The pump casing shall be fitted with case wear rings to minimize abrasive and corrosive wear to the casing. The rings shall be secured to prevent rotation and leakage.
3. Suction and discharge flanges shall be rated for 125# or 250# working pressure for the applicable service.
4. Provide machine enamel finish.

B. The impeller shall be ASTM B62 bronze, enclosed type, vacuum cast in one piece and keyed to the shaft. The impeller shall be hydraulically and dynamically balanced. The impeller supplied shall be of a diameter not greater than 85% of the casing cutwater diameter.

C. Shaft:

1. The pump shaft shall be Type 416 stainless steel, one-piece, finished and polished on all sections. The shaft shall be of ample strength and rigidity. The maximum allowable deflection of the shaft shall be 0.002 inches at any point of operation on the pump curve.
2. Shaft sleeves shall be Type 316 stainless steel and shall be sealed at the impeller hub to prevent pumped liquid from contacting the shaft.

D. Stuffing Box:

1. A stuffing box shall be provided on each side of the pump casing, designed with sufficient area for incorporation of either packing rings or mechanical seals.
2. Each stuffing box shall be furnished with John Crane Type 21 mechanical seals. All metal parts of the seal shall be stainless steel with "Viton" elastomers, Ni-Resist seats and carbon washers.
3. The stuffing boxes shall be fitted with rings of die-cut, non-asbestos, graphited Teflon fiber packing material. A two-piece gland shall be used to secure the packing and to allow access to the packing without disassembly of unit.
4. The mechanical seals on each pump shall be provided with a CUNO Model 1A1 with mounting bracket and five micron filter impurity eliminator. The filter shall be factory-piped and provided with isolating gate valves and valved bypass piping. Piping shall be Schedule 40 galvanized steel pipe. Piping shall be arranged for bypassing impurity eliminator. Eliminator, piping, and valves shall be insulated as specified in Section 23 07 00 entitled "Mechanical Insulation."
5. Provide one set of replacement mechanical seals for each size of pump. After the pumps are in operation for ninety days, the Contractor shall check the seals and replace any that are defective. If the replacement seals are not used during the ninety day operational period, they shall be delivered to the Owner.

E. Bearings:

1. Bearings shall be regreaseable lubrication ball type, designed for 40,000 hours average life. Each bearing shall be mounted in a machined housing that is moisture and dustproof. The housing

shall have registered fits to assure alignment. Each housing shall be supplied with a grease fitting and a plugged relief port.
2. Provide oil lubricated bearings with adjustable oiler to maintain proper oil level. Bearings shall be designed for 250,000 hours average life.

F. A Woods Sure-Flex flexible coupling shall be provided to connect the pump shaft to the motor shaft. The coupling shall be all metal type with a flexible rubber insert. The entire rotating coupling element shall be enclosed by a coupling guard. Coupling alignment and pump vibration shall be field-checked. See the Section 23 05 93 entitled "Testing Adjusting, Balancing and Commissioning" for alignment and vibration tests. Provide factory manufactured coupling guards which comply with OSHA requirements.

G. Pump and motor shall be mounted on a common drip lip type fabricated of hot dip galvanized steel base. The base shall have provisions for grouting, anchor bolts, and collection of all seal leakage. The base shall have machined surfaces for the motor and pump mounting surfaces. Motor mounting shall permit horizontal adjustment. A threaded outlet of 3/4" minimum size shall be provided at the pump end for field piping of drainage to drain. The base shall be of sufficient strength to prevent vibration, warping, or misalignment of the pump and motor when installed without grouting. The base shall be rigidly bolted to the vibration isolation base. After final alignment, all pumps, 25 horsepower and over, shall have the pump and motor doweled to the base. In addition, the minimum requirements of the fabricated structural steel base shall be as follows:

1. For pumps driven by motors 20 horsepower and smaller, the steel base shall be fabricated of formed steel shapes adequately stiffened as required to prevent "oil-canning."
2. For pumps drive by motors 25 horsepower and larger, the steel base shall be fabricated of structural shapes and formed steel section. The main structural member and formed steel sections shall have a depth of at least 1/12 the overall length of the base but not less than four inches. The base shall be filled with concrete or grout after installation on the isolation base.

H. Motor

1. Motors shall be in accordance with Section 23 05 13 of these specifications.
2. Each motor shall have sufficient horsepower rating to operate the pump at any point on the pump's head-capacity curve without overloading the nameplate rating of the motor, regardless of service factor.
3. The motor shall have a service factor of 1.15.

2.3 END SUCTION PUMPS

A. Casing:

1. The casing will be ASTM A48 cast iron of the end suction design with tangential discharge outlet. The casing shall have tapped and plugged holes for priming and draining. The casing bore shall be large enough to allow removal of the impeller without disturbing the casing or suction and discharge piping.
2. The pump casing shall be fitted with a case wear ring to minimize abrasive and corrosive wear to the casing. The case wear ring shall be of the radial type, press fitted into the casing.
3. For suction piping diameters of 2.5 inches or greater and discharge piping diameters of 2 inches or greater, flange connections shall be ANSI 125# rated.
4. Provide machine enamel finish.

B. The impeller shall be ASTM B584 bronze, enclosed type, vacuum cast in one piece, keyed to the shaft and fastened with a washer, gasket and capscrew. It shall be finished smooth and cleaned of all

burrs,

trimmings and irregularities. The impeller shall be hydrostatically and dynamically balanced, and be of a diameter not greater than 85% of the cutwater diameter.

C. Shaft:

1. The shaft shall be Type 416 stainless steel direct-coupled to the power frame shaft. The shaft shall be machined to provide an impeller keyway, and drilled and tapped to accept the impeller fastener. The outboard shaft extension shall be machined with a keyway to accept a coupling to the driving unit.
2. Shaft sleeves shall be Type 316 stainless steel] and shall be sealed to the impeller hub by an O-ring, and shall be positively driven by a pin to the keyway. The use of adhesive compounds to fasten the sleeve to the shaft shall not be accepted.

D. Stuffing Box:

1. The stuffing box shall be integrally cast with a mounting bracket, and shall provide an adequate area for internal recirculation of the pumped fluid around the sealing medium.
2. Each stuffing box shall be furnished with John Crane Type 21 mechanical seals. All metal parts of the seal shall be stainless steel with "Vitron" elastomers, Ni-Resist seats and carbon washers.
3. Provide one set of replacement mechanical seals for each size of pump. After the pumps are in operation for ninety days, the Contractor shall check the seals and replace any that are defective. If the replacement seals are not used during the ninety day operational period, they shall be delivered to the Owner.
4. Provide impurity eliminators for 10 HP and above.

E. The power frame shall house permanently greased ball bearings selected for a 250,000 hours minimum life at maximum load. Lubrication fittings shall be provided in convenient location.

F. The pump unit shall be supported from beneath the mounting bracket and the power frame by mounting feet.

G. Pump and motor shall be mounted on a common drip lip type fabricated of hot dip galvanized steel base. The base shall have provisions for grouting, anchor bolts, and collection of all seal leakage. The base shall have machined surfaces for the motor and pump mounting surfaces. Motor mounting shall permit horizontal adjustment. A threaded outlet of 3/4" minimum size shall be provided at the pump end for field piping of drainage to drain. The base shall be of sufficient strength to prevent vibration, warping, or misalignment of the pump and motor when installed without grouting. Structural steel bases shall be fabricated with continuous welds. Spot welding is not acceptable. Bases shall be hot dipped galvanized after fabrication. The base shall be rigidly bolted to the vibration isolation base. After final alignment, all pumps, 25 horsepower and over, shall have the pump and motor doweled to the base. In addition, the minimum requirements of the fabricated structural steel base shall be as follows:

1. For pumps driven by motors 20 horsepower and smaller, the steel base shall be fabricated of formed steel shapes adequately stiffened as required to prevent "oil-canning."
2. For pumps driven by motors 25 horsepower and larger, the steel base shall be fabricated of structural shapes and formed steel section. The main structural member and formed steel sections shall have a depth of a least 1/12 the overall length of the base but not less than 4 inches. The base shall be filled with concrete or grout after installation on the isolation base.

H. A Woods Sure-Flex flexible coupling shall be provided to connect the pump shaft to the motor shaft.

The coupling shall be all metal type with a flexible rubber insert. The entire rotating coupling element shall be enclosed by a coupling guard. Coupling alignment and pump vibration shall be field-checked. See the entitled, "Testing Adjusting, Balancing and Commissioning" for alignment and vibration tests. Provide factory manufactured coupling guards which comply with OSHA requirements.

I. Motor:

1. Motor shall be in accordance with Section 23 05 13 of these specifications.
2. Each motor shall have a sufficient horsepower rating to operate the pump at any point on the pump's head-capacity curve without overloading the nameplate horsepower rating of the motor, regardless of service factor.
3. The motor shall have a service factor of 1.15. The service factor is reserved for variations in voltage and frequency.

2.4 IN-LINE PUMPS

A. Casing:

1. The casing will be ASTM A48 cast iron of the in-line design. The casing shall have tapped and plugged holes for priming and draining. The impeller shall be easily removed without disturbing the casing or suction and discharge piping.
2. The pump casing shall be fitted with a case wear ring to minimize abrasive and corrosive wear to the casing.
3. Provide machine enamel finish.

B. The impeller shall be ASTM B584 bronze, enclosed type, vacuum cast in one piece, keyed to the shaft and fastened with a washer, gasket and capscrew. It shall be finished smooth and cleaned of all burrs, trimmings and irregularities. The impeller shall be hydrostatically and dynamically balanced.

C. Shaft:

1. The shaft shall be SAE1045 steel direct-coupled to the power frame shaft.
2. Shaft sleeves shall be Type 316 stainless steel.

D. Seals:

1. Seals shall be mechanical type. All metal parts of the mechanical seal shall be stainless steel with "Vitron" elastomers, Ni-Resist seals and carbon washers.

E. Motor:

1. Motor shall be in accordance with Section 23 05 13 of the specifications.
2. Each motor shall have sufficient horsepower rating to operate the pump at any point on the pumps head-capacity curve without overloading the nameplate horsepower rating of the motor, regardless of the service factor.
3. The motor shall have a service factor of 1.15. The service factor is reserved for variations in voltage and frequency.

PART 3 - EXECUTION

3.1 INSPECTION

A. Field verifies all dimensions. If any deviations from the drawings are required by the Contractor, details of such deviations shall be submitted in writing for approval. Deviations shall not be made until written approval has been made.

B. Alignment of the pump, motor and coupling shall be checked, and corrected if necessary, after installation and prior to energizing the pump motor.

3.2 INSTALLATION

A. Install pumps on 4 inch concrete housekeeping pads.

B. Mount pump as specified in Section 23 05 48.

C. Furnish and install gauges and accessories indicated on the drawings and as specified.

D. All fittings, valves, strainers, flexible connections, etc., at each pump shall be full line size. Where required, reduce pipe sizes immediately before and after the pump.

E. Install pumps and all associated accessories, wiring and piping in full accordance with the manufacturer's recommendations.

F. Pump manufacturer's representative shall:

1. Furnish wiring diagram for field wiring.
2. Verify pump alignment.
3. Inspect completed pump installation.
4. Certify in writing that installation and operation of the pump are complete and correct.

END OF SECTION 23 21 23

SECTION 23 23 00 - REFRIGERANT PIPING AND SPECIALTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Refrigerant Piping Systems.

B. Liquid Indicators.

C. Strainers.

D. Refrigerant Driers.

E. Filter-Driers.

F. Solenoid Valves.

G. Expansion Valves.

H. Refrigerant Charging Valves.

I. Flexible Connectors.

1.2 SUBMITTALS

A. Pipe and Pipe Fittings: Manufacturer's data showing materials, ASTM designation, dimensions and schedule.

B. Specialties: Submit manufacturer's product data showing materials, dimensions, capacity and performance data and installation instructions.

C. Refer to Section 23 05 00 for Shop Drawing requirements.

1.3 QUALITY ASSURANCE

A. Install refrigerant specialties in accordance with manufacturer's printed installation instructions.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Specialties:

1. Henry.
2. Sporlan.

2.2 LIQUID INDICATORS

A. Double port type with copper or brass body, and flared or solder ends.

B. Provide removable seal caps on each port for inspection of refrigerant condition.

2.3 STRAINERS

A. Angle type with brass shell and replaceable cartridge.

B. Suitable for refrigerant and piping material utilized in the system.

2.4 REFRIGERANT DRIERS

A. In-line or angle type with copper or brass shell.

B. Employ replaceable desiccant drier material.

2.5 FILTER-DRIERS

A. Angle type, with brass shell and using combined straining and drying material.

B. Employ replaceable desiccant material.

2.6 SOLENOID VALVES

A. Copper or brass body with flared or threaded ends.

B. Use replaceable coil assembly.

C. Provide with operable stem to permit manual operation in case of coil failure.

2.7 EXPANSION VALVES

A. Angle type or straight through design suitable for the refrigerant utilized in the system.

B. Brass body, internal or external equalizer, and adjustable superheat setting, complete with capillary tube and remote sensing bulb.

2.8 REFRIGERANT CHARGING VALVES

A. General purpose type with brass body, flared or solder ends, and removable valve core.

B. Provide valve inlet with quick coupling connection for ease of charging.

2.9 FLEXIBLE CONNECTORS

A. Close pitch corrugated bronze hose with single layer of exterior braiding, 9 inches long (minimum) with bronze fittings.

PART 3 - EXECUTION

3.1 PIPING AND PIPE FITTINGS

A. Type ACR copper tubing, hard temper with wrought copper fittings for systems over 5 tons. For systems 5 tons and less annealed Type ACR tubing may be used.

B. Brazed, phos-copper alloy or bronzed, silver alloy shall be used.

C. Grade and trap piping as necessary to facilitate oil return.

D. Install piping with careful regard to expansion.

E. Joints shall be made up in the presence of dry nitrogen only.

F. Following completion of successful pipe testing, the system shall be charged in accordance with manufacturer's recommendations. System shall be evacuated to a deep vacuum using an approved auxiliary vacuum pump utilizing a vacuum dehydration indicator (dial type gauges will not be acceptable). The vacuum pump shall be operated until a reading of 250 microns, and a wet bulb temperature less than 35 degrees F is obtained. The vacuum pump shall be valved off and the vacuum in the system shall be broken with dry nitrogen. The system shall be evacuated a second time to 250 microns and charged as recommended by manufacturer.

G. Provide expanded rubber insulation on suction return line and paint exterior of insulation with approved pigmented plasticized vinyl lacquer in accordance with manufacturer's specifications.

3.2 TESTING

A. Joints shall be tested with liquid soap and electronic leak detectors, and if a leak is found the joint shall be remade as described above.

B. For piping installed in concealed spaces or buried, test piping before system is concealed or back filled.

C. Joints shall be tested before any coverings are applied using dry nitrogen for liquid soap testing prescribed system refrigerant for electronic leak detectors. High side shall be tested at 400 psig and the low side at 250 psig.

D. After testing, and whenever conditions permit, operate systems at normal operating pressure and temperature for not less than five consecutive days. The piping systems must remain free from leaks during this period.

3.3 LIQUID INDICATORS

A. Provide full size liquid indicators in main liquid line leaving condenser. If receiver is used, install in liquid line leaving receiver.

3.4 STRAINERS

A. Provide full size strainer ahead of each automatic valve. Where multiple expansion valves with integral strainers are used install single main liquid line strainer.

B. Provide shut-off valve on each side of strainer to facilitate maintenance.

3.5 REFRIGERANT DRIERS

A. Provide full flow permanent refrigerant drier in low temperature systems and systems utilizing hermetic or scroll compressors and furnished complete with three-valve bypass assembly.

3.6 FILTER-DRIERS

A. Combination filter/driers may be furnished in lieu of separate strainers and driers; Provide complete three-valve bypass assembly.

3.7 SOLENOID VALVES

A. Provide solenoid valves in liquid line of systems operating with single pump-out or pump-down compressor control, in liquid line of single or multiple evaporator systems and in oil bleeder lines from flooded evaporators to stop flow of oil and refrigerant into the suction line when system shuts down.

3.8 EXPANSION VALVES

A. Locate expansion valve sensing bulb immediately after evaporator outlet on suction line.

B. Select valves for maximum load at design operating pressure and minimum 43 degrees F of superheat.

C. Size expansion valves to avoid of being undersized at full load and excessively oversized at partial load.

D. Evaluate refrigerant pressure drop through system to determine the available pressure drop across each valve.

E. Mount drier vertically in liquid line adjacent to receiver.

3.9 REFRIGERANT CHARGING VALVES

A. Provide refrigerant charging connections in liquid line between receiver shut-off valve and expansion valve.

3.10 FLEXIBLE CONNECTORS

A. Install flexible connectors at or near compressor where it is not physically possible to absorb vibration within rigid piping configuration.

END OF SECTION 23 23 00

SECTION 23 25 13 – CHILLED AND HEATING HOT WATER TREATMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Perform water analysis and provide all water treatment products, holding reservoirs, equipment and labor for testing, cleaning, flushing and dispensing products to control water quality for the chilled and hot water system.

B. Chemicals: Provide, at no additional cost to the Owner, all chemicals required for operating and testing all water treatment systems prior to acceptance by the Owner.

C. Instructions: Provide operating and maintenance instructions for each water treatment system; include one set in each Owner's Manual and deliver one set to Owner's operating personnel.

D. Testing Equipment and Reagents: Furnish suitable water treatment testing equipment for each system, complete with apparatus and reagents necessary for operation until acceptance by the Owner.

E. Service Representative: Furnish the services of a qualified service representative to instruct Owner's operating personnel in proper operation and maintenance of water treatment equipment, systems and tests required. Service representative shall return to the site bi-weekly during first 2 months of operation and monthly during the remainder of the guarantee period. At such times, service representative shall check and adjust water treatment system operation, check efficiency of chemicals and chemical applications, and instruct and advise operating personnel.

F. Replacement and Rework: Replace defective or nonconforming materials and equipment with new materials and equipment at no additional cost to the Owner for 1 year after successful start-up of the system. All warranty work shall be FOB as installed at the project site.

1. Guarantee: Provide system produced by manufacturer who is willing to execute the required guarantee.
2. Agreement to Maintain: Provide system produced by manufacturer who is willing to execute (with the Owner) the required agreement for continued maintenance of the system.

1.2 SUBMITTALS

A. Test Reports: Submit test reports certified by an officer of the firm, on water treatment company letterheads, of samples of each treated water system specified. Comply with ASTM D 596 for reporting. Indicate the ASTM test methods used for each test.

B. Shop Drawings: Submit shop drawings for each water treatment system. Show wiring, piping and tubing sizes, fittings, accessories, valves and connections.

C. Guarantee: Submit written guarantee, signed by the Manufacturer and countersigned by the Installer and Contractor, agreeing to adjust or replace the system or portions thereof as required to achieve the required performance, during a 1-year period following the final start-up.

D. Agreement to Maintain: Prior to the time of final acceptance, the Manufacturer of the water treating system shall submit four copies of and "Agreement for Continued Service and the Owner's possible acceptance." Offer terms and conditions for furnishing chemicals and providing continued testing and servicing and including replacement of materials and equipment for a 1-year period with option for renewal of the Agreement by the Owner.

1.3 QUALITY ASSURANCE

A. Qualifications: The Contractor for work under this Section shall have:

1. Research and development facilities.
2. Regional laboratories capable of making water analyses.
3. A service department and qualified technical service representatives located within a reasonable distance of the project site.
4. Service representatives who are Registered Engineers or factory- certified technicians with not less than 5 years of water treatment experience with the water treatment system manufacturer.

B. Packaging and Labeling: Supply water treatment chemicals in metal drums, fiber drums with plastic liners, or plastic lined "liqui-paks" as best suited to the materials. Paper bags or unlined cardboard cartons will not be acceptable. Use only chemicals in domestic water systems, and all biocides regardless of where used, which are registered with the U.S. Environmental Protection Agency (EPA) and which are labeled as required by law.

C. Electrical Standards: Provide electrical products which have been tested, listed and labeled by Underwriters Laboratories (UL) and which comply with National Electrical Manufacturers' Association (NEMA) standards.

D. Chemical Standards: Provide chemical products acceptable under state and local pollution control or other governing regulations.

PART 2 - PRODUCTS

2.1 GENERAL

A. Water Analysis: Determine which chemicals to use from the results of a water sample analysis taken from the building site by the system manufacturer. Provide ingredients necessary to achieve the desired water conditions.

B. Pre-Treatment: Treat each chilled and hot water piping system with chemicals to remove and permit flushing of mill scale, oil, grease and other foreign matter. Chemicals shall be Nalco 2578 prepping compound.

C. FDA and USDA Approval: Use only FDA and USDA-approved products in systems with direct connection to domestic water systems.

D. Governing Laws: Ensure that neither products, waste, blow-down nor other effluents violate local, state, EPA, or other agency regulations in effect in the project area.

2.2 CHILLED AND HEATING HOT WATER SYSTEMS

A. Chemicals: Provide water treatment products which contain inhibitors that perform the following:

1. Form a protective film to prevent corrosion and scale formation;
2. Scavenge oxygen and protect against scale;
3. Remain stable throughout operating temperature range, and;
4. Are compatible with pump seals and other elements in the system.
5. The inhibitor shall be a boron-nitrate scale inhibitor compound, Nalco No. 2534.

B. Equipment: For each system, provide a 5-gallon pot-type feeder constructed of materials which are impervious to the products dispensed. Feeder shall be designed for not less than 200-psig operating pressure.

C. Test Kit: Provide test kit and reagents for determining proper water conditions.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS PREPARATION

A. General: After piping systems are erected and proven free of leaks, administer chemicals required for preparation treatment and flushing. Apply chemicals for the time period and in the concentration recommended by the water treatment manufacturer for this portion of the work.

B. Testing: Perform test procedures and submit a written report of test conditions and results to the Engineer. If test results are unsatisfactory, repeat preparation treatment as necessary to achieve test results approved by the Owner' insurance carrier and the Engineer.

3.2 FLUSHING

A. General: Drain preparation and boilout products from systems. Flush with clean water until system tests prove systems are free of preparation and boilout products and other contaminants prior to administering system water treatment as specified hereinbefore.

3.3 CHILLED AND HEATING HOT WATER SYSTEMS

A. Treatment: Treat initial water charge to chilled and hot water system, after systems have been flushed and prepped, to achieve a water quality as specified.

B. Start-Up Procedures: During chilled and hot water system start-up, operate after charging with specified chemicals to maintain the required steady-state characteristics of chilled and heating hot water. Demonstrate system operation to Owner's operating personnel.

C. Reports: Prepare certified test report for each required water performance characteristic. Comply with the following ASTM standards, where applicable:

1. D 859-Tests for Silica in Water and Waste Water.
2. D 1067-Tests for Acidity or Alkalinity of Water.
3. D 1068-Tests for Iron in Water and Waste Water.
4. D 1126-Tests for Hardness in Water.
5. D 1128-Identification of Types of Microorganisms and Microscopic Matter in Water and Waste Water.
6. D 3370-Sampling Water.

3.4 PERSONNEL TRAINING

A. Operator Training: Train Owner's personnel in use and operation of water treating systems and or including preparation of chemical solution, if applicable, and charging of the chemical solution reservoir. A program Administration Manual shall be furnished encompassing all systems covered in this section of the Specifications.

END OF SECTION 23 25 13

SECTION 23 25 16 - CONDENSER WATER TREATMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Condenser Water Treatment System.

1.2 DESCRIPTION OF WORK

A. Section Includes: Perform water analysis and provide all water treatment products, holding reservoirs, equipment and labor for testing, cleaning, flushing and dispensing products to control water quality for each system specified hereinafter as follows:

1. Condenser Water System.

B. Chemicals: Provide, at no additional cost to the Owner, all chemicals required for operating and testing all water treatment systems prior to acceptance by the Owner.

C. Instructions: Provide operating and maintenance instructions for each water treatment system; include one set in each Owner's Manual and deliver one set to Owner's operating personnel.

D. Testing Equipment and Reagents: Furnish suitable water treatment testing equipment for each system, complete with apparatus and reagents necessary for operating until acceptance by the Owner.

1. Reagents and apparatus for determination of corrosion inhibitor and oxidizing biocide levels in the recirculating water systems.
2. Reagents and apparatus for determination of TDS or conductivity (umhos) in the system. The TDS or conductivity meter should be a hand held with 4 selectable ranges (0-10, 0-100, 0-1000, and 0-10,000 umhos).

E. Service Representative: Furnish the services of a qualified service representative to instruct Owner's operating personnel in proper operation and maintenance of water treatment equipment, systems and tests required. Service representative shall return to the site bi-weekly during first two (2) months of operation and monthly during the remainder of the guarantee period. At such times, service representative shall check and adjust water treatment system operation, check efficiency of chemicals and chemical applications, and instruct and advise operating personnel.

F. Replacement and Rework: Replace defective or nonconforming materials and equipment with new materials and equipment at no additional cost to the Owner for one (1) year after successful start-up of the system. All warranty work shall be FOB as installed at the project site.

1. Guarantee: Provide system produced by manufacturer who is willing to execute the required guarantee.
2. Agreement to Maintain: Provide system produced by manufacturer who is willing to execute (with the Owner) the required agreement for continued maintenance of the system.

1.3 SUBMITTALS

A. Test Reports: Submit test reports certified by an officer of the firm, on water treatment company letterheads, of samples of each treated water system specified. Comply with ASTM D 596 for

reporting. Indicate the ASTM test methods used for each test.

B. Shop Drawings: Submit shop drawings for each water treatment system. Show wiring, piping and tubing sizes, fittings, accessories, valve and connections.

C. Guarantee: Submit written guarantee, signed by the Manufacturer and countersigned by the Installer and Contractor, agreeing to adjust or replace the system or portions thereof as required to achieve the required performance, during a one (1) year period following the final start-up for continued operation of the condenser.

D. Agreement to Maintain: Prior to the time of final acceptance, the Manufacturer of the condenser water treating system shall submit four copies of an "Agreement for Continued Service and the Owner's possible acceptance". Offer terms and conditions for furnishing chemicals and providing continued testing and servicing and including replacement of materials and equipment for a one (1) year period with option for renewal of the Agreement by the Owner.

1.4 QUALITY ASSURANCE

A. Qualifications: The Contractor for work under this Section shall have:

1. Research and development facilities.
2. Regional laboratories capable of making water analyses.
3. A service department and qualified technical service representatives located within a reasonable distance of the project site.
4. Service representatives who are Registered Engineers or factory-certified technicians with not less than 5 years of water treatment experience with the water treatment system manufacturer.
5. Training of operating personnel on proper feed and control techniques.
6. Service visits and consultation meetings (as needed). At least once per month.
7. Any necessary log sheets and record forms (available upon request)
8. Any laboratory and technical assistance (as needed)
9. Annual corrosion coupon study (60-90 day trial) shall be performed, one sample for mild steel and another for copper. Results shall be forwarded to the owners representative.

B. Packaging and Labeling: Supply water treatment chemicals in appropriate non-metallic drums or delivered safely in a bulk system. Paper bags or unlined cardboard cartons will not be acceptable. Use only chemicals in domestic water systems, and all biocides regardless of where used, which are registered with the U.S. Environment Protection Agency (EPA) and which are labeled as required by law.

C. Electrical Standards: Provide electrical products which have been tested, listed and labeled by Underwriters Laboratories (UL) and which comply with National Electrical Manufacturers' Association (NEMA) standards.

D. Chemical Standards: Provide chemical products acceptable under state and local pollution control or other governing regulations.

1.5 WARRANTY

A. Provide five (5) year parts and labor warranty on centrifugal vortex separator, if specified on plans.

PART 2 - PRODUCTS

2.1 GENERAL

A. Water Analysis: Determine which chemicals to use from the results of a water sample analysis taken from the building site by the system manufacturer. Provide ingredients necessary to achieve the desired water conditions.

B. Pre-Treatment: Treat condenser water piping system with chemicals to remove and permit flushing of mill scale, oil, grease and other foreign matter. Chemicals shall be Nalco 2578 prepping compound.

C. FDA and USDA Approval: Use only FDA and USDA-approved products in systems with direct connection to domestic water systems.

D. Governing Laws: Ensure that neither products, waste, blow-down nor other effluents violate local, state, EPA, or other agency regulations in effect in the project area.

2.2 CONDENSER WATER SYSTEM

A. General: Provide a complete factory-fabricated automatic condenser water treatment system designed to monitor, record and control:

1. System alkalinity in a pH range that is non-corrosive or scaling;
2. Total dissolved solids (TDS); or Conductivity (uS)
3. System blow down;
4. Scaling and corrosion; and
5. Eliminate micro-biological growth.

B. Program: Cooling Tower Controller. Use Walchem WDT-310 Model controller for controlling conductivity and chemical treatment in recirculating cooling water systems. The control system shall be housed in a NEMA 4X lockable fiberglass enclosure.

C. Equipment:

1. Chemical Solution Reservoirs: Shipping containers shall have protective linings which are impervious to the products held and dispensed.
2. Conductivity Monitor- Will provide linear, temperature compensated measurements directly in microsSiemens (uS) over the full range of 0-10,000 uS. The units may be displayed as uS or as ppm TDS (Total Dissolved Solids). Conductivity will be displayed on as easy to read alphanumeric lighted screen. Adjustments for setpoint, manual –off-automated operation, and calibration are made using a front panel mounted keypad.

    a. Feed Control- to allow for changing conditions the control shall incorporate the necessary circuitry and controls for chemical feed:

        (1) Bleed and feed
        (2) Feed as a percentage of bleed
        (3) Feed as a percentage of time
        (4) Feed based on a water meter contactor input
        (5) An integral feed limit timer will be incorporated to prevent overfeed

b. Conductivity Probe- The conductivity probe and a flow switch will be pre-mounted and wired to the controller to simplify installation. The flow switch will interlock the control functions to prevent feed or bleed when sample flow is too low.
c. PH Probe- consists of a double-junction with temperature compensation. Sensor must be compatible with the analyzers used in the system.
d. Biocide Feed- Oxidizing biocide feed will be controlled the same way as the tower inhibitor. For the application of non-oxidizing biocides two (2) programmable timers are available (for non-oxidizing bioicides, an additional chemical pump will be required for each biocide use). Non-oxidizing biocide feed can be set up on 1-day, 1-week, 2-week, 3-week or 4-week cycles. Lockout timers are provided to prevent bleed immediately after biocide feed.
e. Chemical Metering Pumps: Total of 4 needed.

(1) Positive displacement type, diaphragm type with ball check valves shall be provided to feed corrosion inhibitor, oxidizing biocide and non-oxidizing biocide. Feed rate shall be adjustable while pump is running.

f. Pump shall be furnished with foot valves and injection fittings. The pump for the oxidizing biocide shall include a degassing head to prevent air lock.

(1) Minimum discharge working pressure will depend on the pressure of the system. Typically, a pump of 150 PSIG will be sufficient. However, when the chemical feed station is located in the basement of a relatively tall building a pressure of 250 psig might be required
(2) Pump diaphragm, tetrafluoroethylene; head block, polyvinyl chloride (PVC); check valves, PVC with Viton "O" ring seats and ceramic balls.
(3) Motor suitable for 120-volt, 1-phase with totally enclosed gear train.
(4) Acid Pump - recommend using a PVDF head and Teflon fittings for functionality of pump.

g. Corporation Stop:

(1) Four Corporation stops shall be included. They are to be a minimum of 3/4'" inch size and constructed of Kynar. These will be provided to inject chemical directly in the condenser line that supplies the cooling tower. The tip of the corporation stop must reach to the center of the condenser piping to insure prompt mixing of the chemical. The injector will be installed with a ball valve before the thread o let, on the bottom of the pipe. Exact location of the corporation stop shall be determined by the water treatment vendor.

h. Control Panel: Provide control panel consisting of the following:

(1) NEMA 4X cabinet with key-locked, windowed door.

3. pH Measurement: Ensure pH measurement is:
a. Differential-type,
b. Temperature compensated from 0 degrees to 100 degrees C,
c. 0.03 pH per day stability,
d. Two (2) to 12 pH range, and
e. pH probe not requiring solutions or crystal change.

4. Conductivity Measurement: Provide conductivity meter with:
   a. Titanium palladium alloy electrodes,
   b. Temperature-compensation from 0 degrees to 100 degrees C,
   c. Stability of 0.2 percent of full scale per day,
   d. Dual ranges of 0 to 1000 micro-ohms per centimeter and 0 to 5000 micro-ohms per centimeter.

5. Bleed Valve or Bleed-Off Assembly: Provide bleed valve as follows:
   a. Sized to provide the maximum bleed off required as per system tonnage.
   b. Bleed solenoids should be one inch smaller than the size of the make up water meter.
   c. Solenoids shall be installed on the condenser line supplying the tower. It should also be installed with a by-pass for manual bleed of condenser water
   d. Normally closed, brass solenoid valve with Buna-N or ethylene propylene rubber seals rated to operate at system pressure and impervious to system products.
   e. Stainless steel internal wetted parts.

6. Strainer: Provide a cast iron-bodied strainer, with stainless steel strainer element immediately upstream of the bleed valve, rated to operate at system pressure.
7. Corrosion coupon rack- minimum of 2 sampling ports, constructed of schedule 80 PVC, with 0-10 gpm flow indication (no dole valves) and an isolation valve on both ends of the rack.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS PREPARATION

A. General: After piping systems are erected and proven free of leaks, administer chemicals required for preparation treatment and flushing. Apply chemicals for the time period and in the concentration recommended by the water treatment manufacturer for this portion of the work.

B. Testing: Perform test procedures and submit a written report of test conditions and results to the Engineer. If test results are unsatisfactory, repeat preparation treatment as necessary to achieve test results approved by the Owner's insurance carrier and the Engineer.

3.2 FLUSHING

A. General: Drain preparation and boil-out products from systems. Flush with clean water until system tests prove systems are free of preparation and boil-out products and other contaminants prior to administering system water treatment as specified here-in-before.

3.3 CONDENSER WATER TREATMENT SYSTEM

A. Treatment: Treat initial water charge to condenser cooling water system, after system has been flushed and prepped, to achieve a water quality as specified.

B. Start-Up Procedures: During condenser cooling water system start-up, operate condenser water treating system (after charging with specified chemicals) to maintain the required steady-state characteristics of condenser water. Demonstrate system operation to Owner's operating personnel.

C. Reports: Prepare certified test report for each required water performance characteristic. Comply with following ASTM standards, where applicable:

1. D 1067-Tests for Acidity or Alkalinity of Water.
2. D 1126-Tests for Hardness in Water.

3. D 1128-Identification of Types of Microorganisms and Microscopic Matter in Water and Waste Water.
4. D 3370-Sampling Water.

D. Water Chemistry: Where water chemistry substantiates that pH control is not necessary, chemical feed shall be based on water makeup quantities. Water analysis shall be based on the full parameters of operation, and all possible water supplies. A water meter on the makeup water shall be used in conjunction with a conductivity or TDS bleed control. pH control may be omitted where "M" Alkalinity in the condenser water at five (5) cycles of concentration does not exceed 500 PPM, and pH range is 8.2 to 9.4. Total hardness and "M" Alkalinity of the makeup water will be the determining factor along with the technical limitations of the inhibitors.

3.4 PERSONNEL TRAINING

A. Operator Training: Train Owner's personnel in use and operation of condenser water treating systems including preparation of chemical solution, if applicable, and charging of the chemical solution reservoir. A Program Administration Manual shall be furnished encompassing all systems covered in this section of the Specifications.

END OF SECTION 23 25 16

SECTION 23 32 00 - DUCTWORK AND ACCESSORIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Ductwork and accessories including the following:

1. Supply air, return air, outside air and exhaust systems.
2. Duct Leakage Testing.

1.2 DEFINITIONS

A. Seal or sealing: Use of liquid or mastic sealant, with or without compatible tape overlay, or gasketing of flanged joints, to keep air leakage at duct joints, seams and connections to an acceptable minimum.

B. Duct Pressure Classification:

1. Low pressure: Static pressure rating up to 2 inches wg (water gage), positive or negative.
2. Medium pressure: Static pressure rating up to 4 inches wg positive, or 3 inches wg negative pressure.
3. High pressure: Static pressure rating up to 10 inches wg positive pressure, greater than 3 inches wg negative pressure.

C. Exposed duct: Exposed to view in a finished room.

D. Fire Damper Installation: SMACNA Fire, Smoke And Radiation Damper Installation Guide for HVAC Systems) and the manufacturer’s installation instructions shipped with the damper.

1.3 QUALITY ASSURANCE

A. Refer to Paragraph, QUALITY ASSURANCE, in Section 23 05 00, BASIC MECHANICAL REQUIREMENTS.

B. Fire Safety Code: Comply with NFPA 90A, 90B, and 96.

C. Duct System Construction: SMACNA HVAC Duct Construction Standards, First Edition 1985, are minimum acceptable quality. When specific requirements for ductwork are made in the specifications or drawings, these requirements will take precedence over SMACNA Standards.

D. Duct accessories exposed to the air stream, such as dampers of all types and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance.

E. A representative sample of the duct system will be leak tested.

1.4 SUBMITTALS

A. Refer to Paragraph, SUBMITTALS, in Section 23 05 00, BASIC MECHANICAL REQUIREMENTS.

B. Manufacturer's Literature and Data:

1. Ductwork:
   a. Schedules of duct systems, materials, joint and seams, gage and reinforcement type, spacing and pressure class.
   b. Sealants and gaskets.
   c. Duct supports.

2. Access door sizes and construction.
3. Volume dampers, backdraft dampers.
4. Fire dampers, smoke dampers and fire doors with installation instructions.
5. Flexible ducts and clamps, with manufacturer’s installation instructions.
6. Spin in collars with dampers.
7. Flexible connections.
8. Air intake/exhaust hoods.
9. Instrument test fittings.
10. Air flow measuring stations.

C. Construction details of Air Conditioning Apparatus Casing including mounting of coils, filters, etc.

D. Refer to Sections 23 05 00 and 23 05 93 for additional requirements.

PART 2 PRODUCTS

2.1 DUCT MATERIALS

A. General: Except for systems specified otherwise construct ducts, casings, and accessories of galvanized sheet steel. Galvanized sheet steel shall have minimum ASTM A525, G60 coating.

2.2 JOINT SEALING

A. Joint and Seam Sealants – General: The term “sealant” is not limited to materials of an adhesive or mastic nature, but also includes saturated tape systems composed of open-weave fabric strips and gypsum/acrylic wetting activator solutions. Sealants shall be water based and nonflammable.

B. Tape Sealing Systems: Tape shall be 2” wide minimum. Woven-fiber tape impregnated with gypsum mineral compound and modified with acrylic/silicone activator to react exothermically with tape to form a hard, durable, airtight seal. Tape sealing systems shall be equivalent to United McGill Uni-Cast Series of products.

C. Adhesive/Mastic Sealing Systems: Sealant shall be a one-part, nonsag, vinyl copolymer system with a minimum of 69% solids. Sealant shall be suitable for application with a caulking gun. Sealant shall be equivalent to United McGill United Duct Sealer Series of products.

. Mechanical Joint Sealing Systems: Commercially produced prefabricated mechanical joint assembly and construction systems may be utilized where applicable. Mechanical Joint Sealing Systems shall be equivalent to Ductmate System of products.

2.3 LOW PRESSURE DUCTWORK

A. Low pressure ductwork, gages, reinforcement, joints, seams, sealing, fittings, supports and other

details shall be in accordance with SMACNA HVAC Duct Construction Standards except as modified below.

B. Gages: Low pressure ducts shall be constructed in accordance with Table 1-5 except that the minimum sheet metal thickness shall be 24 gauge.

C. Cross Joints: The following limitations shall apply to the cross joints listed below.

1. Standing drive slips will not be acceptable.
2. Single Standing S slips will not be acceptable.
3. Hemmed S, inside slip and double S slips may be used in combination with a drive slip for duct sides not exceeding 24" long.
4. Double Standing S slips (T10, T11, T12) will be acceptable for duct sides not exceeding 30" long provided that both upstream and downstream sides of the slip joint are sealed at the junction of the duct and the slip.

D. Combination cross joints of Double Standing S or Pocket Lock slips on the long side and flat drive slips on the short side are acceptable provided the length limitations stated in 3) and 4) are not exceeded.

E. Joint spacing or joint/reinforcement spacing for approved joints such as Ductmate, Nexus, etc.

Maximum duct size (large side)		24"	32"	40"	48"	60"	70"
Pressure	Joint Size	Max. spacing between joints and stiffeners					
up to 2"	7/8" Flange ht.	78"	60"	48"	24"	--	--
	1 3/8" Flange ht.	78"	60"	48"	40"	32"	32"

F. Seams: Button punch snap lock seams shall be sealed along their entire length. Sealant may be applied during or after construction.

G. Elbows: All elbows having a side length less than 12" in the plane of rotation shall be standard radius elbows. Elbows with side length 12" or greater, may be, standard radius, short radius with internal concentric full length splitters bolted to duct sides or square with turning vanes as SMACNA Fig. 2-2 page 2-3. Short radius elbow splitters shall be positioned to ensure that the first splitter radius does not exceed twice the throat radius of the elbow. Subsequent splitters radii shall not exceed twice the previous splitter radius.

H. Offsets: Offsets shall be formed as partial angle radius elbows. 90 degree turning vanes will not be acceptable. Mitered offsets will be acceptable provided the angle of offset does not exceed 30 degrees.

I. Branches: All branch connections shall be provided with a manual volume control damper in the branch duct adjacent to the main duct. Rectangular 90 degree branch connections shall connect to the main duct with a 6" long 45 degree taper on the leading edge. Circular 90 degree branch connections shall connect to the main duct with conical or bell mouth connectors. Circular branch connections to an air outlet device may use a spin-in collar fitting.

J. Volume Dampers: Single blade or opposed blade, multi-louver type as detailed in SMACNA Standards, Figures 2-14 and 2-15. Provide end bearing for all dampers. Quadrant or other

operator for externally insulated duct shall have stand-off mount so operation is clear of the insulation.

K. Automatic Operated Dampers: Section 23 09 00 – Building Energy Monitoring and Control.

L. Backdraft Dampers: Self-operating, multi-blade damper to open fully on 0.06 inch wg pressure difference and close by gravity. Aluminum, 16 gage frame, 0.023 inch blades of flat or elliptical shape, with tie-bar to connect blades for parallel operation. Provide resilient gasket for air seal and quiet operation. Blade pivots shall be in nylon bushings. Provide adjustable counter-balance weight(s) where indicated.

2.4 MEDIUM/HIGH PRESSURE DUCTWORK

A. Gages, joints, seams, reinforcement, fittings, supports and other details for rectangular, round and flat oval duct shall be in accordance with SMACNA, HVAC Duct Construction Standards except as modified below.

B. Gages: Medium pressure rectangular ducts shall be constructed in accordance with Table 1-7 except that 24 gage sheet metal thickness shall be restricted to ducts with sides not exceeding 12" long.

High pressure rectangular duct, shall be constructed in accordance with Table 1-9 except that the minimum sheet metal thickness shall be 22 gage.

Circular ducts shall be constructed in accordance with Table 3-2 using the 10" pressure column. Flat oval ducts shall be constructed in accordance with Table 3-4.

C. Cross Joints:

1. Slip joints (flat drive, S, Pocket Lock, etc.) will not be acceptable for high pressure ducts. Single Standing S slips will not be acceptable for medium pressure ducts.
2. Flat drive slips on medium pressure ducts shall not be used for duct sides exceeding 16" long. Duct reinforcement shall be in accordance with Table 1-18.
3. Double Standing S slips (T10, T11, T12) will be acceptable for medium pressure duct construction for duct sides not exceeding 24" long provided that both the upstream and downstream sides of the slip joint are sealed to meet the duct leakage criteria. The Contractor shall understand that extensive use of S slips in medium pressure duct installations may render the duct system unable to meet the pressure/leakage requirements referenced in Part 3 of this specification.
4. Joint spacing or joint/reinforcement spacing for approved joints such as Ductmate, Nexus, etc.

Maximum duct size (large side)		24"	32"	40"	48"	60"
Pressure	Joint Size	Maximum spacing between joints and stiffners				
up to 4"	7/8" Flange ht.	48"	32"	24"	--	--
	1-3/8" Flange ht.	64"	48"	40"	32"	24"
up to 10"	7/8" Flange ht.	48"	24"	--	--	--
	1-3/8" Flange ht.	48"	40"	32"	24"	--

D. Seams: Button punch snap lock seams will not be acceptable for high pressure ducts.

E. Round and Flat Oval Ducts: Furnish duct and fittings made by the same manufacturer as the straight duct to insure good fit of slip joints.

1. Elbows: Diameters 3 through 10 inches shall be die stamped, all others shall be gored construction with all seams continuously welded as Fig. 2-4. Coat galvanized areas of fittings damaged by welding with corrosion resistant aluminum paint or galvanized repair compound.
2. Provide bellmouth, conical tees, laterals, reducers, and other low loss fittings as shown in SMACNA Standards. Square branches will not be acceptable.

F. Provide flat side reinforcement of flat oval ducts as SMACNA Fig. 3-6, *Type 2. Do not use internal tie-rod reinforcement unless approved by the Engineer.

G. Duct Hangers and Supports: Comply with SMACNA HVAC Duct Construction Standards, Section IV. Trapeze hangers for round duct will not be acceptable.

2.5 DUCT ACCESS DOORS, PANELS AND SECTIONS

A. Provide hinged access doors with handle locks, sized and located for maintenance work, upstream where possible, in the following locations:

1. Each coil and humidifier.
2. Each fire damper (for link service), smoke damper and automatic control damper.
3. Each duct mounted smoke detector.
4. Each change in direction, at required intervals and at grease reservoirs of kitchen exhaust ducts for cleaning.

B. Openings shall be as large as feasible in small ducts, 12 inch by 12 inch minimum where possible and 18 inch x 18 inch in 20 inch or wider cuts. Access doors in insulated ducts shall be double-wall, insulated, and mounted on stand off frames to insulation thickness.

1. For rectangular ducts: Refer to SMACNA (Figure 2-12).

C. All access doors shall be labeled (1/2" high lettering) to indicated device to be serviced.

2.6 CURTAIN TYPE FIRE DAMPERS (DYNAMIC STYLE)

A. Galvanized steel, out of air stream interlocking blade, curtain type fire damper with UL listing and label. 1-1/2 hour rating, 165 degrees F, fusible link, with pressure drop performance equal to blade stack out of air stream. Provide fire dampers where indicated on the drawings and where required by local codes.

B. Fire dampers for grilles, where walls will not accommodate standard fire dampers, shall be thin line type, same construction as standard fire dampers.

C. Dampers shall be furnished with sleeves in accordance with UL 555.

D. All dampers shall be in accordance with NFPA 90A and in accordance with UL for the fire rating indicated.

2.7 COMBINATION FIRE AND SMOKE DAMPERS

A. Acceptable Products/Manufacturers:
   1. Greenheck Model FSD-33.
   2. Prefco Model No. 5020-1 with Model No. 5920-1 damper operator/resettable link set for closure of the FSD at 165 degrees F or higher temperature.
   3. Ruskin Model No. FSD 60 with Model No. TS 150 Firestat (or fusible link for dampers designated to open on a loss of power).

B. Construction: Heavy duty, high quality, multiple blade dampers with flexible stainless steel blade edge seals to provide constant sealing pressure. Fabricate with 16 gauge galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, stainless steel jamb seals, 1/8 inch x 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock, and 1/2 inch actuator shaft.

C. The maximum air pressure drop through the damper shall not exceed 0.10 inch water gauge at the design air quantity. Note: This may require a larger damper than the connected duct size**.**

D. Each damper shall be furnished in a square or rectangular configuration. The Contractor shall furnish and install sleeves manufactured by the approved damper manufacturer for each damper. The sleeves shall be constructed with square or rectangular to square, rectangular, round, or oval adapters as required. Dampers shall be installed in the sleeves in accordance with manufacturers U.L. installation instructions. The entire assembly, following installation, shall be capable of withstanding six (6) inch W.G. static pressure.

E. Smoke Control Mode Damper Motor Actuator:
   1. General: Damper actuators shall be provided as an integral component by the combination fire and smoke damper manufacturer and shall be factory installed and adjusted.
   2. Actuators shall be UL listed and labeled spring return, electric type.
   3. Actuators shall meet the following additional requirements:
      a. Be fully accessible for ease of maintenance. Shop Drawings shall clearly indicate actuator location on multiple section damper assemblies.
      b. Stroke the damper from fully open to fully close and vice-versa in less than seventy-five (75) seconds.
      c. Fail Safe Modes:
         (1) Return Air: Power open/spring closed.
         (2) Supply Air: Power closed/spring open.
      d. Provide, at minimum, one (1) damper actuator for each 16 square feet of operable damper face area or as recommended by the manufacturer, whichever is the more stringent requirement.
      e. Provide sufficient quantity of additional damper actuators to meet the damper leakage requirements for the installed damper assembly at the maximum close-off leakage requirements as specified herein.
      f. Provide mounting brackets suitable for extended shaft mounting. Locate damper actuator on exterior of duct and link to damper operating shaft.
      g. Shall not be able to drive damper while the fire safety mode damper operator link is released.
      h. Shall be controllable by a signal initiated by the building Fire Alarm System.

F. Fire Safety Mode Damper Operator:
   1. All combination fire and smoke dampers shall incorporate one (1) UL classified (with reopenable fire damper rating that does not preclude fire heat closure) fire safety mode operator that performs the following features:

a. Extended shaft damper drive transmission with linear control and in-heat actuator disconnect.
b. Smoke detector signaled damper motor actuator override.
c. Spring closed.
d. Mechanical lock upon closure that is independent of motor actuator position or condition.
e. Automatic reset upon cessation of smoke detector signal (test or actual fire), heat, and normalization of duct air temperature.

2. Operator shall be a heat-actuated release device which permits controlled closures through the actuator.

G. Required Accessories:
1. Provide factory sleeve and collar for each damper.
2. Damper Position Indicator Switch: Provide damper position indicator switches which are an integral part of the damper actuators or are linked directly to damper blades for indication of both the fully open and fully closed positions on FSD. Damper position indicator switches shall be factory mounted and adjusted by the damper manufacturer.
3. Furnish all required relays, EP switches, wiring, piping and other labor and material necessary to completely interconnect the damper to the Fire Alarm System.

H. Listings: All combination fire and smoke dampers shall be UL labeled under the following testing and classification standards:
1. Dampers
a. UL 555 fire endurance rating:
(1) 1-1/2 hour for walls/partitions rated less than three (3) hours.
(2) Three (3) hours for walls/partition rated three (3) hours or more.
(3) Class I at 550 degrees F.
b. UL 555S - low leakage rated damper for use in smoke control systems:
(1) The damper and damper actuator shall be furnished as an integral unit meeting the elevated temperature qualification of UL 555S at 250 degrees F.
(2) Maximum Leakage Rate: Eight CFM per square foot of overall damper face area at four (4) inch W.G. differential pressure and four (4) CFM/square feet. at one (1) inch W.G. The leakage rate of the field installed damper shall not exceed the Class I UL rating.
c. Dampers shall meet all the requirements of smoke dampers per the latest edition of NFPA 90A and 92A.
2. Fire fail safe mode links: UL 33.
3. Fire Damper Operators: UL 873 and reopenable rated under UL 555.

2.8 FLEXIBLE CONNECTIONS

A. Where duct connections are made to fans and air handling units, install a non-combustible flexible connection of 29 ounce neoprene coated fiber glass fabric approximately six inches wide. For connections exposed to sun and weather provide hypalon coating in lieu of neoprene. Burning characteristics shall conform to NFPA 90A. Refer to SMACNA Standards Section 2, Fig. 2-19. Flexible connections to be United McGill Corporation, Ventglas for supply and return ducts inside the building and Ventlon for all ducts exposed to the weather including outside air intake and wet exhaust ducts.

2.9 INSTRUMENT TEST FITTINGS

A. Manufactured type with a minimum two inch length for insulated duct, and a minimum one inch length for duct not insulated. Test hole shall have a flat gasket for rectangular ducts and a

concave gasket for round ducts at the base, and a screw cap to prevent air leakage.

B. Provide instrument test holes at each duct or casing mounted temperature sensor or transmitter, and at entering and leaving side of each heating coil, cooling coil, sound attenuator and duct mounted filter units.

2.10 AIR FLOW MEASURING STATIONS

A. General: Provide solid state electronic-sensing air flow measurement systems as specified, and in the locations indicated on the Plans. Any conflict between the locations indicated and the manufacturer's placement guidelines for optimum performance shall be resolved by the Contractors involved, with changes subject to the approval of the Engineer and the equipment manufacturer.

B. The electronic air measurement system (EAMS) shall be a true and totally solid state electronic device comprised of the following:

1. A thermistor-based sensor grid.
2. A microprocessor-based electronics for flow averaging, temperature compensation and signal transmission. Air sampling and velocity pressure measurement equipment shall not be acceptable.
3. The EAMS shall be EBTRON or approved equal.
4. Each EAMS sensor grid shall consist of a lattice network of thermistors and linear IC's, situated inside an aluminum casing suitable for mounting in a duct. Each thermistor sensor shall be recess mounted within a strut, facing downstream of the air flow, and located so that it is protected on the upstream side. All wiring shall be Teflon or Kynar coated and encased (out of the air stream) to protect against mechanical and environmental damage.
5. Sensor density per duct size, for Outside Air Intake, or for Supply, Return and Exhaust measurements, shall conform to the following (when flow rates are expected to fall below 1000 fpm):

Duct Free Area (ft^2)	Sensor Density (Typ.)
Less than 4	4 Sensors/ft^2
4 to 16	16 Sensors/unit
greater than 16	1 Sensor/ft^2

6. The contractor may use either a flanged or slot-fit (insertion-type) grid frame style. Sensors installed in ducts shall be insertion type. The casing (frame) shall be made of all-welded aluminum to the specific dimensions of the ducts for which each grid is intended to be installed. Each grid frame shall be of sufficient strength to prevent structural bending or bowing, after having been installed in accordance with the manufacturer's instructions. The contractor shall also supply gasketing to seal the grid frame to the duct system, as required.

C. EAMS stations designated to measure Outside Air Intake (OA) shall be capable of functioning accurately between -20°F and +160°F, and in ducts sized for a maximum face velocity (at the intake louver) of 400 fpm. Manufacturer's placement recommendations and guidelines for OA measurement shall be strictly observed.

D. Each sensor grid casing and electronics enclosure shall have a permanently mounted tag, showing: matching serial numbers, the system's output signal, full scale reading, flow capacity, size, actual internal flow area. Direction of flow will be indicated on the interior and exterior of the casing.

E. The electronics package shall consist of an enclosure which houses a completely solid-state microprocessor, permanent non-volatile memory, regulated power supply and a software-based system. (Optional - Each EAMS electronics package shall be capable of indicating a system malfunction, yet continue to operate and avoid a system shut-down; while simultaneously indicating a malfunction to the user.)

F. The electronics shall have the ability to transmit signals of 0-5 vdc or 4-20 mA as required by the controls hardware, for use in the control of the HVAC system.

G. These signal outputs shall be linear and available for both flow and temperature measurement. The system shall have the capability to accept user-defined scaling parameters for all output signals.

H. A single temperature-compensated average flow output signal shall be provided for each ducted location shown on the drawings. When multiple locations are required to achieve a single total flow, then one signal may be provided which will equal the sum of these locations.

I. Each electronics package shall be powered by a separate or isolated, single phase 24 vac or 24 vdc power source and shall be protected from line surges and transients. Optionally, a 120 vac or 240 vac power source may be utilized when transformed to 24 vac, as specified. Multiple EAMS's may be powered from a single transformer, when the manufacturer's installation instructions are strictly followed.

J. The measurement system, which includes all components required to produce a linear-to-flow, temperature-compensated electronic output, shall be factory calibrated with a Total Accuracy of +/-(2% of Reading, +20 fpm) across a total calibrated range of zero to 5000 fpm. Temperature measurement accuracy shall be better than +/-0.5EF from Reading. Field calibration shall not be required, when the manufacturer's minimum placement guidelines are followed. Pressure drop shall not exceed 0.005 in. WG (water gauge) at 2000 fpm. Repeatability shall be +/-0.4% of reading or better.

K. Total EAMS Accuracy shall include and depend upon: temperature-compensation, humidity, repeatability, turbulence and placement. Any changes in duct configuration and/or changes in the physical placement of the grid array or duct accessories, as specified or recommended by the EAMS manufacturer is to be submitted and approved by the Engineer.

L. The successful contractor is required to submit independent laboratory test results, verifying the station's accuracy potential, repeatability, and the effects of duct loading on output accuracy. Regular or periodic field maintenance shall not be required.

2.11 FLEXIBLE AIR DUCT, LOW PRESSURE - TYPE LP

A. General: Factory fabricated, comply with NFPA 90A. Flexible ducts shall not penetrate any fire or smoke barrier. Provide only where permitted by local codes and licensing standards. Maximum length of flexible duct shall be six feet.

B. Insulated Flexible Air Duct: Factory made including chlorinated polyethylene fabric mechanically locked to steel helix without the use of adhesives or chemicals. Duct innsulation shall be mineral fiber with maximum C factor of .23 at 75 degrees F. mean temperature, encased with a reinforced metalized fire retardant vapor barrier outer jacket.

C. Flexible ducts shall be UL 181, Class I Air Duct.

D. The internal working pressure rating shall be at least 6" w.g. positive and 4" w.g. negative (up to 16 inch diameter) with a bursting pressure of at least 2-1/2 times the working pressure.

E. Acoustical performance, when tested by an independent laboratory in accordance with the Air Diffusion Council's Flexible Air Duct Test Code FD 72-R1, Section 3.0, Sound Properties, shall be as follows:

The insertion loss (dB) of a 10 foot length of straight duct when tested in accordance with ASTM E477, at a velocity of 2500 feet per minute, shall be at least:

OCTAVE BAND	2	3	4	5	6	7
Hz	125	250	500	1000	2000	4000
6" diameter	7	31	40	38	40	27
8" diameter	13	29	36	35	38	22
12" diameter	21	28	29	33	26	12

The radiated noise reduction (dB) of a 10 foot length of straight duct when tested in accordance with ASTM E477, at a velocity of 2500 feet per minute, shall be at least:

OCTAVE BAND	2	3	4	5	6	7
Hz	125	250	500	1000	2000	4000
6" diameter	5	8	7	8	11	15
8" diameter	10	7	7	8	10	13
12" diameter	9	6	6	5	9	13

The self-generated sound power levels (LW) dB re 10^{-12} Watt of a 10 foot length of straight duct for an empty sheet metal duct when tested in accordance with ASTM E477, at a velocity of 1000 feet per minute, shall not exceed:

OCTAVE BAND	2	3	4	5	6	7
Hz	125	250	500	1000	2000	4000
6" diameter	42	31	23	18	17	21
8" diameter	41	34	27	19	18	21
12" diameter	54	45	38	31	27	23

F. Flexible ducts shall be Flexmaster Model 1M or equal.

2.12 FLEXIBLE AIR DUCT, HIGH PRESSURE - TYPE HP

A. General: Factory fabricated, comply with NFPA 90A. Flexible ducts shall not penetrate any fire or smoke barrier. Provide only where permitted by local codes and licensing standards. Maximum length of flexible duct shall be six feet.

B. Insulated Flexible Air Duct: Factory made including trilaminate fabric mechanically locked to steel helix without the use of adhesives or chemicals. Duct insulation shall be mineral fiber with maximum C factor of .23 at 75 degrees F mean temperature, encased with a reinforced metalized fire retardant vapor barrier outer jacket.

C. Flexible ducts shall be UL 181, Class I Air Duct.

D. The internal working pressure rating shall be at least 12" w.g. positive and 5" w.g. negative (up to 16" diameter) with a bursting pressure of at least 2-1/2 times the working pressure.

E. The duct shall be rated for a velocity of at least 5500 feet per minute.

F. Flexible ducts shall be Flexmaster Model 3M or equal.

2.13 FLEXIBLE CONNECTIONS

A. Where duct connections are made to fans and air handling units, install a non-combustible flexible connection of 29 ounce neoprene coated fiber glass fabric approximately six inches wide. For connections exposed to sun and weather provide hypalon coating in lieu of neoprene. Burning characteristics shall conform to NFPA 90A. Refer to SMACNA Standards Section 2, Fig. 2-19. Flexible connections to be United McGill Corporation, Ventglas for supply and return ducts inside the building and Ventlon for all ducts exposed to the weather including outside air intake and wet exhaust ducts.

PART 3 - EXECUTION

3.1 DUCT SEALING

A. Seal all transverse joints and all duct wall penetrations of low pressure ducts.

B. Seal all traverse joints, longitudinal joints and duct wall penetrations of medium pressure ducts.

C. Ductwork installed in mechanical rooms, unoccupied utility spaces and concentrated above finished ceilings shall have the joints sealed as follows: Seal joints and seams by applying layers of glass fabric tape embedded in coat of Foster 32-19 sealant. Tape shall overlap the joint a minimum of two inches. Apply finish coat of sealant to completely cover the tape.

D. Ductwork installed exposed to view in occupied spaces shall have two joints sealed as follows: Seal joints with adhesive/mastic sealant in accordance with manufacturer’s instructions except that at external joints, apply sealant to joints with caulking gun in narrow bead. Do not apply sealant to exterior of ductwork with brush.

E. Apply sealant within the slip joints of round and flat oval ducts during construction. Additionally, seal the joints as described above.

F. Mechanical joint seals shall have all corners securely fastened with bolts/flange clips. On ducts 24” and larger, max bolt spacing shall not exceed 12” O.C.

3.2 DUCT LEAKAGE TESTING

A. Randomly test 10% of all duct systems for leakage in accordance with Section 4 of SMACNA HVAC Air Duct Leakage Test Manual. If leakage test results exceed SMACNA's allowable

leakage rates, then entire duct systems shall be tested.

B. The duct system shall be tested in sections at a static pressure equal to or greater than the highest static pressure duct classification contained in the system.

C. Leakage test pressure and allowable leakage (including exhaust ducts):

1. Low pressure ducts: Test pressure 2", allowable leakage shall not exceed 0.3 cfm/sf duct surface area.
2. Medium pressure ducts: Test pressure 4", allowable leakage shall not exceed .04 cfm/sf duct surface area.

3.3 FIRE DAMPERS

A. Fire dampers, including their sleeves shall be installed in accordance with the conditions of their listing and the manufacturer's installation instructions. Provide labeling of the Fire Damper on the outside of duct.

3.4 CONTROL DAMPER INSTALLATION

A. Provide necessary blank-off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size.

B. Assemble multiple section dampers with required interconnecting linkage and extend number of shafts through duct for external mounting of damper motors.

C. Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation, and affix and seal permanently in place, only after stratification problem has been eliminated.

3.5 PROTECTION AND CLEANING

A. Adequately protect material against physical damage. Protect material and ducts during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting. When new ducts are connected to existing ductwork, clean both new and existing ductwork inside and outside before operation. Clean ducts shall be free of all foreign matter including oil and other residue.

3.6 DUCT LEAKAGE REPAIR

A. Repair all audible leaks.

3.7 SCHEDULE OF MATERIALS

AIR SYSTEM	MATERIAL
Systems with VAV or Constant Volume Terminal Units:	
Supply duct from air handling unit to terminal unit	Medium pressure construction
Supply duct downstream of terminal units	Low pressure construction

AIR SYSTEM	MATERIAL
General:	
Return air ducts	Low pressure construction
Outside air ducts	Low pressure construction
Exhaust ductwork	Low pressure construction

END OF SECTION 23 32 00

SECTION 23 34 14 - FANS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Ceiling or In-line Cabinet Fans.

B. In-Line Centrifugal Fans.

C. Roof or Wall Mounted Centrifugal Fans.

D. Utility Vent Sets.

E. Propeller Fans.

1.2 QUALITY ASSURANCE

A. Fans shall be tested and rated in accordance with AMCA requirements for both sound and air flow performance.

B. Fans shall bear AMCA rating seals for both sound and air flow performance.

1.3 SUBMITTALS

A. Submit product data including dimensional data, material specifications, capacity data and installation procedures.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Ceiling or In-Line Cabinet Fans

1. Acme
2. Cook
3. Greenheck.
4. PennBarry.

B. In-Line Centrifugal Fans: (small fans)

1. Acme.
2. Cook.
3. Greenheck.
4. PennBarry.

C. Roof or Wall Mounted Centrifugal Fans:

1. Acme.
2. Cook.

3. Greenheck.
4. PennBarry.

D. Utility Vent Sets:

1. Acme.
2. Cook.
3. Greenheck.
4. PennBarry

E. Propeller Fans:

1. Acme.
2. Cook.
3. Greenheck.
4. PennBarry

2.2 CEILING OR IN-LINE CABINET FANS

A. Fans shall be direct driven or belt driven as scheduled.

B. Casing shall be fabricated of galvanized steel and have a removable panel to allow service of the fan and drive assembly without dismantling the fan. Housing shall have collars for duct connections and equipped with an exhaust grille when furnished in ceiling configuration.

C. Fans wheels shall be backward inclined centrifugal type statically and dynamically balanced.

D. Motors shall be self-cooled with air from outside the duct system. Belt driven units shall have drives sized for 120% of the motor nameplate rating and adjustable sheaves. Fan bearings for in-line configuration shall be permanently lubricated pillow block ball bearings or cast iron lubricated bearings.

2.3 ROOF OR WALL MOUNTED CENTRIFUGAL FANS

A. Fans shall be direct driven or belt driven as scheduled.

B. Fan housing shall be of heavy gauge spun aluminum construction, upblast or downward discharge as scheduled, be weatherproof, and incorporating an integral weather shield.

C. Fans shall be furnished with features (i.e. bird screen, back-draft dampers, built-in prewired disconnect switch, roof curb, extended roof curb, sound attenuating roof curbs) as scheduled.

D. Fan wheels shall be statically and dynamically balanced and shall have a spun venturi inlet.

E. Motor and fan assembly shall be suspended on neoprene vibration isolating mounts.

F. Motors shall be self-cooled with air from outside the duct system. Direct drive unit motors shall be located in a compartment separate from the exhaust air stream. Belt driven units shall have drives sized for 150% of the motor nameplate rating and adjustable sheaves. Fan bearings shall be permanently lubricated pillow block ball bearings or cast iron lubricated bearings.

G. Where used for kitchen hood exhaust, fans shall be upblast type and be UL 762 listed.

H. Where scheduled, direct drive units 1/2 hp and smaller shall have speed controls mounted on the fan housing. Direct drive units 3/4 hp and larger shall have remote mounted speed control.

2.4 UTILITY VENT SETS

A. Fans shall be direct driven or belt driven as scheduled.

B. The housing and frame shall be constructed of aluminum or steel with an enamel finish structurally reinforced to withstand the pressures involved and support the fan and motor. Discharge arrangement shall be as shown on the drawings. Scroll shall be bolted in place (not welded) and be capable of being rotated in the field. Provide drain in bottom of scroll and flanged connections.

C. The utility vent set fan wheel shall be of the centrifugal type either forward curved, backward inclined or airfoil as scheduled on the drawings. The fan wheel shall be aluminum, galvanized steel or steel. The rotating assembly shall be statically and dynamically balanced at the factory and be stable throughout the operating range of airflows. The fan shall be keyed to solid carbon steel shaft and mounted in self aligning pillow block ball bearings having a minimum average life of 40,000 hours.

D. Motors shall be self-cooled with air from outside the duct system. Belt driven units shall have drives sized for 150% of the motor nameplate rating and adjustable sheaves. Fan bearings for in-line configuration shall be permanently lubricated pillow block ball bearings or cast iron lubricated bearings.

E. Weather Housing: The motor and drives shall be protected from weather by a steel or aluminum weather cover with louvers for motor ventilation.

2.5 PROPELLER FANS

A. Fans shall be direct driven or belt driven as scheduled.

B. Fan housings shall be of heavy gauge spun aluminum construction, formed galvanized steel, or steel with an enamel finish.

C. Fans shall be furnished with features (i.e. wall mounting collar, inlet and/or discharge wire guard built-in disconnect switch) as scheduled.

D. Fan wheels shall be statically and dynamically balanced. Tip speed, rpm, and motor horsepower shall not exceed the maximums scheduled on the drawings. Propeller blades shall be constructed of die formed steel with reinforcing gussets welded to each blade and to the hub or be aluminum blades riveted to steel hub as scheduled..

E. Motor pulleys shall be cast iron machined sheaves. The drive belt and sheaves shall be sized for a minimum of 150% of the driven horsepower. Shafts shall rotate in heavy duty ball bearing pillow blocks. Bearings shall be selected for a minimum average life of 40,000 hours at maximum operating speed.

F. Fan panel shall be made of steel construction and form an inlet venturi for the fan wheel.

G. Motors will be permanently lubricated and installed with neoprene isolators between motor support and motor to minimize vibration.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's recommendations.

B. Provide flexible connections at inlet and outlet for fans except grease hood exhaust and wall or roof mounted propeller fans.

C. Roof mounted fans shall be installed on roof curbs provided by the fan manufacturer.

D. Propeller wall fans shall be mounted in collars provided by the fan manufacturer.

END OF SECTION 23 34 14

SECTION 23 36 00 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fan Induction Terminal Units.

B. Single and Dual Duct VAV Terminal Units.

1.2 QUALITY ASSURANCE

A. Variable volume terminal units shall be tested and rated in accordance with ARI Standard 880.

B. Insulation shall have U.L. or E.T.L. approval meeting NFPA 90A.

C. Electric Heating Coils shall include all safety devices as approved by U.L. or E.T.L.

1.3 SUBMITTALS

A. Submit product data showing unit sizes, inlet and discharge information, scheduled air volume and box pressure drops.

B. Submit sound power levels in decibels re 10^{-12} W in each octave band for discharge and casing radiation.

C. Submit heating capacity, motor data and sound attenuator data.

D. Submit dimensional data (include attenuator dimensions if attenuators are furnished).

E. Submit manufacturer's installation instructions and maintenance and operating procedures.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Metalaire.

B. Titus.

C. Nailor Industries

2.2 PERFORMANCE

A. Terminal units shall be of sizes and capacities scheduled on the Drawings.

B. The terminal unit shall be designed to maintain essentially constant primary air flow regardless of inlet duct connection configuration or upstream duct static pressure fluctuations. A hard duct elbow connected at an angle up to 90 degrees to assembly shall not alter the maximum or the minimum factory air flow setting by more than plus or minus 5%.

2.3 FAN POWERED TERMINAL UNITS

A. Variable Primary Air Volume Fan-Powered Terminal Units:

1. Furnish and install variable primary air volume fan-powered terminal units as indicated on the Drawings. The units shall be provided with a primary variable air volume damper that controls the primary air quantity in response to a temperature control signal. The devices shall contain a fan and motor assembly, and an electric heating coil where scheduled and/or indicated on the Drawings. The fan shall provide a constant volume of discharge air at all air blending ratios from minimum to maximum scheduled primary air quantities and zero to 100% return air flow rates and shall be controlled in sequence as outlined hereinafter. The space limitations shall be reviewed carefully to ensure all boxes will fit in the space allowed including National Electric Code clearances required in front of all panels containing electrical devices. Provide an access door or doors to service all internal components and a removable panel to service the fan and electric motor. The access doors on all devices shall have cam latches. Provide a filter rack with a 1" thick throw-away filter.

2. The unit shall include all equipment and controls as required to provide a complete and operating system with at least the following equipment and controls:

    a. Single point electrical connection for the voltage/phase as scheduled on the Drawings.
    b. Circuit breaker or fused disconnect switch sized to protect all device electrical components.
    c. Individual electrical protection devices as required to protect individual devices and transformers.
    d. A fan speed control system.

3. Provide a multi-point flow sensor device that will control the maximum primary cfm for the terminal unit to that indicated on the Drawings through a transducer and a DDC microprocessor. A multipoint flow sensor shall be located in the primary duct connection and in a position to accurately control the fan supply cfm. The primary inlet shall be equipped with a gradual transition (SMACNA Construction Standards) as required to connect to the primary duct size shown on the Drawings. The transitions shall be provided and installed by the device manufacturer or field installed by the Division 23 Mechanical Subcontractor. The transition shall provide at least a 4" length with a 1/8" high raised bead approximately 1-1/2" from the inlet connection. The primary and fan design cfm settings shall be clearly and permanently marked on the bottom of the unit along with the device identification numbers. Provide a transformer with 24 volt AC secondary to provide power for the device controls. The VAV terminal unit manufacturer and the Building Controls Contractor shall verify compatibility of multipoint sensor with transducer and DDC microprocessor furnished under BCS prior to bidding this Project. The multipoint flow sensors and flow transducers shall be capable of controlling the terminal unit discharge air volume (CFM) to within five (5) percent of scheduled design fan air volume (CFM). The test shall be conducted in an independent testing laboratory acceptable to the Engineer and Owner to prove compatibility of the DDC control system and the fan-powered terminal device at various primary flow rates from 250 fpm to 3000 fpm and the accuracy of the discharge air volume (CFM). The test may be witnessed by the Engineer and Owner. Test results shall be submitted to the Engineer and Owner for review.

4. Fan motor assembly shall be a forward curved centrifugal fan with a direct drive motor. Motors shall be General Electric energy Saver or Fasco Model 7126 specifically designed for use with a speed control device. Motors shall incorporate low-loss electromagnetic steel with both rotor and stator annealed for minimum eddy current losses. Stators shall have the necessary copper content (slot fill), and rotors open aluminum bars to insure stability and minimum generated noise at a reduced voltage input of 40% of rated value. Provide isolation between fan motor assembly and unit casing to minimize any vibration from unit casing. Provide anti-back rotation system or provide a motor that is designed to overcome reverse rotation and not affect life expectancy.

B. VAV Terminal Device Electric Heating Coils:

1. Electric heater coils shall consist of open coils of highest grade 80% nickel, and 20% chromium resistance wire or nichrome elements and insulated with ceramic, phenolic, or lava insulators in aluminized steel, galvanized steel, or stainless steel brackets, supported in heavy gauge aluminized or galvanized steel frames. Each electric heating coil shall be constructed and installed in accordance with the requirements of the local authorities and shall be UL or ETL approved and listed.
2. Coils shall have the capacities scheduled on the Drawings.
3. Terminal bolts, nuts and washers shall be of corrosion resistant materials. Coils shall be constructed so the installation may be accomplished in accordance with the provisions of the National Electric Code, for zero clearance. Coils to be given a 2000 volt dielectric test.
4. Automatic reset thermal cutouts shall be furnished for primary protection with heat limiters in power circuits for secondary protection. Both devices shall be serviceable through terminal box without removing heating element from the VAV terminal device.
5. Heaters shall have a terminal box and cover, with built-in magnetic or mercury step controlled contactors for each circuit, branch circuit fusing for each 48 amp circuit per NEC, and a static pressure or air flow switch for installation in the heater control enclosure. Contactors mounted in ceiling above occupied tenant spaces shall be magnetic or mercury type. Provide a separate 120 to 24 volt fused control power transformer with primary and secondary protection and a disconnect.
6. All wiring of built-in devices shall be brought to clearly mark terminal strips. A complete wiring diagram shall be permanently attached to the terminal device cover or the terminal device.
7. Electric heater coils shall be designed for operation with the DDC controller and control system.
8. Duct heater coils shall be constructed to mount on the discharge of the terminal device.

C. The primary air damper shall be of a design that shall vary primary air supply in response to an electronic signal. Damper leakage at shutoff shall not exceed 4% of the scheduled maximum fan cfm at 1" w.g. Submit damper leakage test data to the Engineer for review. Damper connection to the operating shaft shall be a positive mechanical connection to prevent any slippage. Provide non-lubricated delrin or mylar bearings for the damper shaft. The primary air damper in conjunction with the DDC microprocessor furnished shall be selected to provide control at low primary air velocities. The total deviation in primary air flow shall not exceed +5% of the primary air cfm corresponding to a 250 fpm air velocity through the primary air valve at 0.2 to 2" w.c. inlet static or alternate low flow control logic shall be provided to offset low flow deviation, subject to Engineer's approval. The primary air flow fidelity shall be laboratory demonstrated and proven with any inlet configuration and inlet static variation from 0.2 to 2.0 inches w.g. Dampers shall be life cycle tested to at least 10,000 cycles.

D. A mixing chamber to provide mixing of primary air and plenum air from 100% primary air to 0% primary air, with a temperature variation four feet downstream of the device as specified hereinafter.

E. Provide duct inlet and outlet connections as indicated on the Drawings. Provide factory-mounted primary inlet gradual duct transitions as specified hereinbefore.

F. Limit the terminal unit radiated noise to maximum sound level indicated by NC 35 curve in the occupied space when installed above the ceiling material specified in another Division of the Specifications.

G. Treatment to limit the self-generated discharge noise to an amount that will not produce more than an NC 35 sound level in the occupied tenant space when installed in the duct system as indicated on the Drawings.

H. Every size unit at the scheduled design conditions shall be sound laboratory tested in a mockup of a typical 15' x 15' tenant office. The laboratory mockup test shall use the specified ceiling light fixture, Project ceiling height, Project ceiling plenum depth, and typical ductwork. The terminal units shall be mounted directly above the lighting fixtures at the height indicated on the Drawings. The test will be conducted in accordance with test procedures approved by the Engineer and the acoustical consultant to demonstrate compliance with the NC 35 acoustical criteria within the tenant space. If the VAV fan-powered terminal unit manufacturer has conducted the hereinbefore specified acoustical mockup test and compatibility test with the DDC controller, and with the Owner's typical conditions, and has demonstrated to the Engineer and Owner compliance with the specified acoustical (NC 35) performance and compatibility, the previous testing will be accepted and will not need to be repeated. Mockup tests will be witnessed by the Engineer and Owner and the acoustical consultant.

I. Terminal units shall be constructed of 1” double wall insulated with galvanize sheet metal interior liner and with the exterior wall having not less than 22 gauge. Mounting connections for hanging the device by sheet metal straps shall be clearly identified on the housing. All components, including all controls and wiring, shall be factory installed, except the room sensor or thermostat. No field assembly will be allowed.

2.4 SINGLE DUCT VAV TERMINAL UNITS

A. Casing: Casing shall be constructed of 1” double wall insulated with galvanize sheet metal interior liner and with the exterior wall having not less than 22 gauge.

B. Provide a multi-point flow sensor device that will control the maximum cfm for the terminal unit to that indicted on the Drawings through a transducer and a DDC microprocessor. A multi-point flow sensor shall be located in the primary duct connection and in a position to accurately control the supply cfm. The primary inlet shall be equipped with a gradual transition (SMACNA Construction Standards) as required to connect to the duct size shown on the Drawings. The transitions shall be provided and installed by the device manufacturer or field installed by the Division 23 Mechanical Subcontractor. The transition shall provide at least a 4" length with a 1/8" high raised bead approximately 1-1/2" from the inlet connection. The design cfm settings shall be clearly and permanently marked on the bottom of the unit along with the device identification numbers. Provide a transformer with 24 volt AC secondary to provide power for the device controls. The VAV terminal unit manufacturer and the Building Controls Contractor shall verify compatibility of multi-point sensor with transducer and DDC microprocessor furnished under BCS prior to bidding this Project. The multi-point flow sensors and flow transducers shall be capable of controlling the terminal unit discharge air volume (CFM) to within five (5) percent of scheduled design fan air volume (CFM). The test shall be conducted in an independent testing laboratory acceptable to the Engineer and Owner to prove compatibility of the DDC control system and the terminal device at various primary flow rates from 250 fpm to 3000 fpm and the accuracy of the discharge air volume (CFM). The test may be witnessed by the Engineer and Owner. Test results shall be submitted to the Engineer and Owner for review.

2.5 DUAL DUCT TERMINAL UNITS

A. Casing: Casing shall be constructed of 1" double wall insulated with galvanize sheet metal interior liner and with the exterior wall having not less than 22 gauge.

B. Air Volume Dampers: Control dampers shall be located inside the unit and shall be constructed from extruded aluminum or galvanized zinc coated steel. The cold deck damper and the hot deck damper shall be designed to provide linear control throughout the operating range of both. Control of both dampers shall be in proportion to the actuators movements regardless of the valve openings. The dampers shall seal against the gasketed stops and total leakage of the dampers shall not exceed 5% at three inch inlet static pressure at each duct inlet.

2.6 ELECTRIC COILS

A. Open type 80% nickel, 20% chromium wire.

B. Insulated by ceramic bushings and supported in a galvanized steel frame with intermediate supports 4 inch on center.

C. Integral control panel with primary and secondary over temperature protection, fuses, airflow switch, control transformer and step controls.

2.7 HOT WATER COILS

A. Minimum 1/2 inch O.D. copper tubes with mechanically bonded plate or spiral aluminum fins. Minimum tube thickness shall be .024 inches.

B. Copper headers.

C. Maximum 5 Ft./Sec. water velocity in tubes.

D. Maximum 10 fins/inch.

2.8 ELECTRONIC CONTROLS

A. Electronic controls to be provided by the local approved Control System Contractor.

2.9 WIRING

A. Provide 120V to 24V transformer for control power.

B. Terminal units when supplied to the site shall be suitable for a single power connection.

C. Provide enclosures for control devices and power transformer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install items in accordance with manufacturer's instructions and as shown on the Drawings.

B. Terminal unit manufacturer's flow charts and instructions for field balancing shall be attached to each unit.

C. Terminal units shall have flow measuring taps installed by the unit manufacturer.

D. Provide temporary filters on all fan powered terminal units for use during construction. Remove filters prior to building occupancy.

END OF SECTION 22 36 00

SECTION 23 37 13 - AIR DISTRIBUTION DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Supply, Return, Transfer and Exhaust Air Devices and Accessories.

1.2 SUBMITTALS

A. Submit in accordance with Section 23 05 00.

B. Submit product data and shop drawings covering each item together with schedule of outlets, listing cfm, neck velocity, NC level and Ak factor and air flow measurement procedures.

C. Submit manufacturer's installation instructions.

1.3 QUALITY ASSURANCE

A. Manufacturer shall perform air flow tests and sound level measurements for the products specified.

B. Manufacturer shall certify cataloged performance and ensure correct application of air outlet types.

1.4 JOB CONDITIONS

A. Review requirements of outlets as to size, finish, and type of mounting prior to submitting shop drawings and schedules of outlets.

B. Check location of outlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Krueger.

B. Metal Aire.

C. Price.

D. Titus.

E. Nailor Industries

2.2 GENERAL REQUIREMENTS

A. Provide air devices equal in all respects to those scheduled on the drawings.

B. All air devices shall be the product of one manufacturer.

C. Rate units in accordance with ASHRAE standards.

D. Base air outlet application on space noise level of NC 25 maximum in all areas.

E. Provide supply outlets with sponge rubber seal around edge.

F. Provide plaster frame for diffusers located in plaster surfaces.

G. All devices shall be factory finished.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install items in accordance with manufacturer's printed instructions.

B. Seal square to round adapters airtight to diffusers or grilles using duct sealant system suitable for materials and service.

END OF SECTION 23 37 13

SECTION 23 37 24 - AIR INLET AND OUTLET LOUVERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Outside Air Louver.

B. Exhaust/Relief Air Louver.

1.2 SUBMITTALS

A. Submit manufacturer's product data indicating performance data, louver size, materials, finish, mounting type and accessories.

1.3 QUALITY ASSURANCE

A. Louvers shall be rated in accordance with AMCA Standard 500 for water penetration and louver performance.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Air Balance Inc.

B. Arrow United.

C. AWV.

D. Louvers & Dampers, Inc.

E. Ruskin.

F. Nailor Industries

2.2 FIXED LOUVERS

A. Frame: 6063T5 extruded aluminum .081" wall thickness with caulking slots.

B. Blades: 6063T5 extruded aluminum .081" wall thickness. Blades at approximately 3" centers at 37-1/2 deg. angle.

C. Screen: Expanded flattened aluminum bird screen 3/4" x .051" mounted on rear.

D. Finish: Anodized finish, See drawing for color.

E. Frame: Box (Provide front flange if indicated on drawings).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fasten box frame to construction with bolts through clip angles.

B. Caulk around frame for weather tight perimeter.

END OF SECTION 23 37 24

SECTION 23 41 00 - AIR CLEANING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Disposable Media Panel Filters.

B. Disposable Cell Panel Filters.

C. Moderate Efficiency Panel Filters.

D. Medium Efficiency Extended Surface Filters.

E. High Efficiency Extended Surface Filters.

F. Unitary Holding Frames.

G. Side Access Housings.

1.2 SUBMITTALS

A. Submit in accordance with Section 23 05 00.

B. Submit shop drawings of factory fabricated assemblies.

C. Submit catalogue data showing equipment capacity and dimensions to verify that the equipment meets or exceeds performance and capacity specified.

D. Manufacturer's installation instructions.

E. Submit product test report including all details as prescribed in ASHRAE Standards 52.2, including Appendix J.

F. Submit Manufacturer’s written performance guarantee letter where specified.

1.3 QUALITY ASSURANCE

A. Select filter media that is UL listed, Class I or Class II.

B. Manufacturer's published performance characteristics shall be supported by approved independent laboratory test reports.

C. When dust holding capacity is not published in the manufacturer's literature the submittal data shall include recent certified documentation of performance by an approved independent test laboratory.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Assemble filter components to form filter banks from products of one manufacturer.

B. Size, media face area, ASHRAE certified test efficiency, dust holding capacity, initial and final air resistance of alternative manufacturers shall be same as types specified.

C. Manufacturer:

1. Camfil-Farr.
2. American Air Filter.
3. Cambridge.

2.2 MODERATE EFFICIENCY PANEL FILTERS (TYPE A)

A. Construction: Air filters shall be medium efficiency ASHRAE pleated planels consisting nof cotton and synthetic media, welded wire support grid, and beverage board enclosing frame.

B. Media: 4 inch deep panel, cotton and synthetic blend, pleated to provide a media surface 4.6 times as great as the filter face area, bonded to and supported by a 96 percent free area wide grid of welded wire. Welded wire grid to be spot welded on one-inch centers, treated for corrosion resistance, and shall be bonded to the downstream side of the media to maintain radial pleats and prevent media oscillation.

C. Cell Sides: Rigid, high wet-strength beverage board of no less than 28-point, bonded to media around entire perimeter to prevent bypass, with diagonal bracing integral to the beverage board and bonded to the apex of each pleat on entering air and leaving air faces to maintain uniform pleat spacing in varying airflows.

D. Efficiency: Air Filter shall have a Minimum Efficiency Reporting Value of MERV 8 when evaluated under the guidelines of ASHRAE Standard 52.2-2007. It shall also have a MERV-A of 8 when tested per Appendix J of the same standard. The media shall maintain or increase in efficiency over the life of the filter.

E. Dust Holding Capacity: Not less than 100 grams of ASHRAE Test Dust per 1,000 cu.ft./minute of rated capacity when operated at 500 feet/minute to a final resistance of 1.0 inch w.g.

F. Initial Resistance: 0.27” w.g. at 500 feet/minute.

G. Energy Cost Index (ECI) Value: The filter shall have an ECI Value of not less than 5 Stars.

H. UL Classification: The filter shall be classified by Underwriters Laboratories as UL Class 2.

I. The Manufacturer shall provide evidence of facility certification to ISO 9001:2000.

J. Manufacturer shall guarantee the integrity of the filter pack to 2.0” w.g.

K. Performance Guarantee: Manufacturer shall provided written performance guarantee to owner at time of bid and during submittal phase. Filters not including a written performance guarantee equal to that of the Camfil-Farr 30/30 are unacceptable unless the bidder includes an allowance to the owner at time of bid to cover any additional future costs associated with the failure of the proposed product to meet these specifications. AT NO TIME WILL THE OWNER ACCEPT ADDITIONAL POST-BID COSTS FOR PRODUCTS UNABLE TO MEET THIS SPECIFICATION.

Manufacturer: Camfil-Farr Company Type 30/30.

2.3 MEDIUM EFFICIENCY EXTENDED SURFACE FILTERS (TYPE B)

A. Media: High density, microfine, lofted glass fibers, laminated to and strengthened by a non-woven synthetic backing, preformed into a totally rigid, deep pleated, disposable element. Media supported in the air stream by a welded wire grid bonded to its leaving air face and by contour stabilizers inserted between the pleats on both the entering air and leaving air faces. 100% of the media surface shall be presented to the air flow at all times, regardless of the per cent turndown in the air delivery of variable air volume systems.

B. Frames: Rigid, light gauge, galvanized steel, continuously bonded internally to the filter pack. Protective diagonal support members on both the air entering and air leaving faces. Cell to be capable of withstanding a pressure drop as high as 10" w.g. without distortion.

C. Efficiency: Air Filter shall have a Minimum Efficiency Reporting Value of MERV 11, 13 or 14 as specified when evaluated under the guidelines of ASHRAE Standard 52.2-2007. It shall also have a MERV-A of 11 when tested per Appendix J of the same standard. The media shall maintain or increase in efficiency over the life of the filter.

D. Dust Holding Capacity: Not less than 175 grams of ASHRAE Test Dust per 1,000 cu.ft. per minute of rated capacity when operated at 500 feet/minute to a final resistance of 1.0 inch w.g.

E. Initial Resistance: 0.35" w.g. at 500 feet/minute.

F. Energy Cost Index (ECI) Value: The filter shall have an ECI Value of not less than 4 Stars.

G. UL Classification: The filter shall be classified by Underwriters Laboratories as UL Class 2.

Manufacturer: Farr Company RIGA-FLO 15.

2.4 HIGH EFFICIENCY EXTENDED SURFACE FILTERS (TYPE C)

A. Construction: Air filters shall be V-Bank mini-pleat fiberglass disposable type with pleat separators, polyurethane pack-to frame sealant, and polystyrene enclosing frame. The filter outlet shall be radial in shape with a maximum of 60% open area to maintain low-pressure drop and uniform airflow (20” by 20” shall be straight V-style design). The enclosing frame shall include top and bottom molded tracks as an integral part of the frame to ensure a proper seal.

B. Media: High density, microfine, lofted glass fibers formed into uniform pleasts with a spacking of 10 pleats per inch and uniform pleat height of 24mm. Pleasts shall be separated at 25 mm intervals to ensure pleat separation and uniform airflow through the filter pack. Media packs shall be recessed at

least 1” from the air entering side of the enclosing frame to allow uniform airflow when a prefilter is mounted directly to the enclosing frame. 100% of the media surface shall be presented to the air flow at all times, regardless of the per cent turn down in the air delivery of variable air volume systems.

C. Frames: Rigid plastic end caps shall be mechanically fastened to the top and bottom of the media pack enclosing structure to ensure a rigid and durable filter. Cell to be capable of withstanding a pressure drop as high as 10" w.g. without failure of the media pack.. Carrying handles shall be an integral part of the filter frame and shall bridge from media pack to media pack providing additional filter support and filter rigidity. Handles shall include fastener connection locations for the applications of spring mounting fasteners when the filter is applied in reverse flow applications.

D. Efficiency: The filter shall have Minimum Efficiency Reporting Value of MERV- 13, 14 or 16 as specified when evaluated under the guidelines of ASHRAE Standard 52.2. It shall also have a MERV-A rating of 13, 14 or 16 as specified when evaluated under ASHRAE Standard 52.2, Appendix J.

E. Dust Holding Capacity: Not less than 120 grams of ASHRAE Test Dust per 1,000 cu.ft. per minute of rated capacity when operated at 500 feet/minute to a final resistance of 1.0 inch w.g.

F. Initial Resistance: Shall not exceed 0.60" w.g. at 500 feet/minute for product of any size.

G. UL Listing: Filter shall be listed UL 900 by Underwriters Laboratories.

H. Energy Cost Index (ECI) Rating: Filter shall have a 5-Star rating when evaluated per Energy Cost Index

I. The Manufacturer shall provide evidence of facility certification to ISO 9001:2008

J. Manufacturer: Camfil-Farr Durafil ES.

K. Performance Guarantee: Manufacturer shall provided written performance guarantee to owner at time of bid and during submittal phase. Filters not including a written performance guarantee equal to that of the Camfil-Farr Durafil ES are unacceptable unless the bidder includes an allowance to the owner at time of bid to cover any additional future costs associated with the failure of the proposed product to meet these specifications. AT NO TIME WILL THE OWNER ACCEPT ADDITIONAL POST-BID COSTS FOR PRODUCTS UNABLE TO MEET THIS SPECIFICATION.

2.5 UNITARY HOLDING FRAMES

A. Construction: Factory fabricated from minimum 16 gauge galvanized steel, pre-punched for field assembly into banks. Minimum 2.69 inch depth for structural strength and to prevent racking of frame assembly. Polyurethane foam gaskets and four spring loaded fasteners per frame. Designed to accommodate combination of pre-filters and final filters with only alteration being a change of fasteners.

B. Front or rear access, as shown on the plans. Frames to be compatible dimensionally with the standard filter products.

C. Manufacturer: Camfil-Farr Type 8 Holding Frame.

2.6 SIDE ACCESS HOUSINGS

A. Assembly: Factory assembled, all welded, 16 gauge galvanized steel construction with neoprene gasketed, hinged, access doors on both sides. Latches and hinges to be capable of field replacement (bolted or riveted to housing). Access doors of double wall construction with 1 inch one lb. density fiberglass insulation between inner and outer walls. Housings to incorporate factory prepunched standing flanges for ease of attachment to adjacent equipment or ductwork. Maximum depth of housing (in direction of air flow) not to exceed 21 inches. Top and bottom panels of housing to be factory insulated with 1" one pound density fiberglass encased in 20 gauge galvanized steel outer casing.

B. Internal Hardware: Furnish extruded aluminum tracks with provision for receiving both the primary filters and 4-inch deep pre-filters. Primary filters shall be mounted in slide-in type holding frames capable of accepting the standard size products of any manufacturer without alteration to the hardware. Polyethylene seals inserted into retainers in the aluminum extrusions, on the downstream side of the holding frames, and polyurethane foam strips on the external vertical surfaces of the holding frames, shall make it unnecessary to purchase replacement filters with factory applied gasketing. Housing dimensions shall be such that frames fit snugly against each other to prevent bypass of unfiltered air. Loose sheet metal baffles will not be acceptable. The housing shall be designed so there is a two (2) inch space between each filtration stage.

C. Manufacturer: Camfil-Farr Model 3P Glide/Pack.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Erect and set in place in strict accordance with manufacturer's installation instructions. Particular care shall be given to caulking between frames of unitary holding frame filter banks. Perimeter of assembled filter banks shall be thoroughly caulked at seams between filter bank and inside of filter plenum.

B. Provide a differential pressure gauge (manometer) across each filter row equal to Dwyer, Mark II, Model 25

3.2 TEMPORARY FILTERS

A. Temporary Filters: Do not start up fan systems without filters in place. Where applicable, filters are not to be put in place until time of final acceptance.

B. Filters are to be operated in accordance with the following procedures:

1. Moderate Efficiency Panel Filters: Install Moderate Efficiency Panel at start-up. Furnish Owner with an extra set of clean moderate efficiency filters at the completion of the Project.

2. Medium High Efficiency Extended Surface Filters: Install Medium Efficiency Extended Surface Filters at start-up. Furnish Owner with an extra set of clean Medium Efficiency Extended Surface Filters at the completion of the Project.

END OF SECTION 23 41 00

SECTION 23 41 01 - AIR FILTERATION UP-GRADE--

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Filter Frame Modification.

B. Air Handling unit Testing & Balancing.

C. Air Cleaning Filters.

D. Unitary Holding Frames.

E. Side Access Housings.

1.2 SUBMITTALS

A. Submit in accordance with Section 23 05 00.

B. Submit shop drawings of air handling modification process.

C. Submit certified test and balance report for supply fan indicating the total air volume quantity before and after air filtration Modification.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Filter section supplied by the original air handling unit manufacturers.

B. Assemble filter components to form filter banks from products of one of the manufacturer as specified in section 23 41 00.

C. Size, media face area, ASHRAE certified test efficiency, dust holding capacity, initial and final air resistance of alternative manufacturers shall be same as types under section 23 41 00.

PART 3 - EXECUTION

3.1 FILTRATION UPGRADE PROCESS

A. The design individual shall visit the site to determine options and the required modification to the Air Handling unit.

B. The air handling unit fan performance shall be determined by a certified Test and Balance contractor before any modification is performed. The test shall include the initial measurement of

the total CFM delivered, fan static pressure and fan motor full load Amps.

C. If the existing air handling unit has previous side access housing for secondary filters, reuse the same section and provide filter media as per section 23 41 00.

D. If the existing air handling unit does not have provision for secondary filter but is of a vintage that offers the option for the original unit manufacturer to provide the side access filter housing then, remove the mixing box from the unit and replace the filter section accordingly. Modify the ductwork connections as required to reconnect the out side air and return air ductwork to the relocated existing mixing box. Provide pre-filter and after-filter media as per section 23 41 00.

E. If the air handling unit manufacturer is no longer in business or does not produce the filter section for the model of the unit to be retrofitted then, remove the mixing box from the unit and replace the filter section with a side access housing as specified under section 23 41 00. Modify the connections as required between the air handling unit and the new filter section and mixing box. Modify and reconnect the ductwork as required.

F. The pressure drop due to the filter modification shall be added to the original air handling static pressure. The fan belt and sheaves shall be replaced to maintain the total original fan CFM. If the sheave change places the operation of the fan at or above the full load amp. rating of the original motor then, replace motor and related electrical connection as required.

G. As much as possible, the housing shall be selected to accommodate standard 24”x24”filters (nominal size).

3.2 COORDINATION WITH AT&T

A. The contractor shall coordinate and schedule the air handling shutdown and modification with the AT&T project manager

B. The contractor shall comply with AT&T Service Protection Guideline.

END OF SECTION 23 41 01

SECTION 23 52 16 - FUEL-FIRED CONDENSING BOILERS

PART 1 - GENERAL

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. This Section includes the following fuel-fired water heaters:

1. Commercial, high-efficiency, gas boiler.
2. Water heater accessories.

1.3 SUBMITTALS

A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Product Certificates: For each type of commercial and instantaneous water heater, signed by product manufacturer.

D. Operation and Maintenance Data: For water heaters to include in emergency, operation, and maintenance manuals.

E. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain same type of water heaters through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of water heaters and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. ASHRAE/IESNA 90.1-2004Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004.

E. ASME Compliance:

1. Where ASME-code construction is indicated, fabricate and label commercial boiler to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1.5 COORDINATION

A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

1.6 WARRANTY

A. Special Warranty

1. Provide a Bumper-to-Bumper Warranty to include Part and Labor for a period of 5 years from the date of substantial completion.

PART 2 - PRODUCTS

2.1 COMMERCIAL, GAS WATER HEATERS

A. Commercial, High-efficiency Gas Water Heaters

1. The boiler shall have the scheduled capacities and shall be operated on natural gas. The water heater shall be capable of full modulation firing down with a turn down ratio of 5:1. The boiler shall bear the ASME “H” stamp and shall be National Board listed for inputs in excess of 200,000 Btu/Hr. There shall be no banding material, bolts, gaskets or “O” rings in the header configuration. The 316L stainless steel combustion chamber shall be designed to drain condensation to the bottom of the heat exchanger assembly. The complete heat exchanger assembly shall carry a ten (10) limited warranty. The water shall be supplied with condensate neutralization kit.
2. The boiler shall be certified and listed by C.S.A. International under the latest edition of the harmonized ANSI Z21.10.3 test standard for the US and Canada. The water heater shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 901. Standard. The boiler shall operate at a minimum of 92% thermal efficiency. The boiler shall be certified for indoor installation.
3. The water heater shall be constructed with a heavy gauge steel jacket assembly, primed and prepainted on both sides. The combustion chamber shall be sealed and completely enclosed, independent of the outer jacket assembly, so that integrity of the outer jacket does not affect a proper seal. A. burner/flame observation port shall be provided. The burner shall be a premix design and constructed of high temperature stainless steel with a woven metal fiber outer covering to provide modulating firing rates. The water heater shall be supplied with a gas valve designed with negative pressure regulation and be equipped with a variable speed blower system, to precisely control the fuel/air mixture to provide modulating water heater firing rates for maximum efficiency. The water heater shall operate in a safe condition at a derated output with gas supply pressures as low as 4 inches of water column.
4. The boiler shall utilize a 24 VAC control circuit and components. The control system shall have boiler status, and boiler diagnostics. All components shall be easily accessed and serviceable from the front of the jacket. The boiler shall be equipped with a temperature/pressure gauge; high limit temperature control with manual reset; ASME certified pressure relief valve set for 50 psi (standard); outlet water temperature sensor; return water temperature sensor; outdoor air sensor, flue temperature sensor; high and low gas

pressure switches, low ater cut off with manual reset and a condensate trap for the heat exchanger condensate drain.

5. The boiler shall be equipped with two terminal strips for electrical connection. A low voltage connection board with 30 data points for safety and operating controls, i.e., Alarm Contacts, Runtime Contacts, Louver Proving Switch, two Flow Switches, Tank Thermostat, Remote Enable/Disable (Wall Thermostat/Zone Control), System Supply Sensor, Outdoor Sensor, Tank Sensor, Modbus Building Management System signal and Cascade control circuit. A high voltage terminal strip shall be provided for Supply voltage. Supply voltage shall be 120 volt / 60 hertz / single phase. The boiler may be factory trimmed for optional supply voltages, i.e., 208 volt / 60 hertz / 3 phase, 480 volt / 60 hertz / 3 phase and 240 volt / 50 hertz / single phase. The high voltage terminal strip plus integral relays are provided for independent pump control of the System pump, the Boiler pump and the Domestic Hot Water pump. The system pump and boiler pump dry contacts shall be sized for up to 1.5 hp/120V, 3hp/240V or 30 amp pumps.
6. The boiler shall utilize a 24 VAC control circuit and components. The control system shall have an electronic display for boiler set-up, boiler status, and boiler diagnostics. All components shall be easily accessed and serviceable from the front and top of the jacket. The boiler shall feature a control panel with a 2-line, 16 character LCD display, password security, pump delay with freeze protection, pump exercise and PC port connection. The boiler shall allow 0-10 VDC input connection for BMS control and have built-in controls to sequence and alternate the boiler without utilization of an external controller.

7. The boiler shall be installed and vented with one of the following items:

    a. Direct Vent system with horizontal sidewall termination of both the exhaust vent and combustion air. The flue shall be Category IV approved Stainless Steel sealed vent material terminating at the sidewall with the manufacturer's specified vent termination. A separate pipe shall supply combustion air directly to the boiler from the outside. The air inlet pipe must be sealed and may be other materials listed in the Installation manual. The boiler's total combined air intake length shall not exceed 100 equivalent feet. The boiler's total combined exhaust venting length shall not exceed 100 equivalent feet. The air inlet must terminate on the same sidewall as the exhaust.
    b. Direct Vent system with vertical roof top termination of both the exhaust vent and combustion air. The flue shall be Category IV approved Stainless Steel sealed vent material terminating at the rooftop with the manufacturer's specified vent termination. A separate pipe shall supply combustion air directly to the boiler from the outside. The air inlet pipe must be sealed and may be other materials listed in the Installation manual. The boiler's total combined air intake length shall not exceed 100 equivalent feet. The boiler's total combined exhaust venting length shall not exceed 100 equivalent feet. The air inlet must terminate on the rooftop with the exhaust.
    c. Vent system with Vertical rooftop or Horizontal sidewall exhaust with the combustion air intake in different pressure zones. The flue shall be Category IV approved Stainless Steel sealed vent material terminating at the rooftop or sidewall with the manufacturer's specified vent termination. A separate pipe shall supply combustion air directly to the boiler from the outside in a different pressure zone from that of the exhaust vent. The air inlet pipe must be sealed and may be other materials listed in the Installation manual. The boiler's total combined air intake length shall not exceed 100 equivalent feet. The boiler's total combined exhaust venting length shall not exceed 100 equivalent feet.
    d. Vertical rooftop or Horizontal sidewall exhaust with the combustion air drawn from the equipment room. The flue shall be Category IV approved Stainless Steel sealed vent material. The boiler's total exhaust venting length shall not exceed 100 equivalent feet.

Combustion air draw from the equipment room shall be supplied with properly sized combustion and ventilation air openings based on NFPA requirements.

8. The water heater shall have an independent laboratory rating for Oxides of Nitrogen (NO_x) of 30 ppm or less, corrected to 3% 02.
9. The Boiler shall be suitable for use with polypropylene glycol, up to 50% concentration without contingencies.

2.2 BOILER ACCESSORIES

A. Gas Shutoff Valves: ANSI Z21.15/CGA 9.1, manually operated. Furnish for installation in piping.

B. Gas Pressure Regulators: ANSI Z21.18, appliance type. Include pressure rating, capacity, and pressure differential required between gas supply and water heater.

C. Gas Automatic Valves: ANSI Z21.21, appliance, electrically operated, on-off automatic valve.

D. Combination Temperature and Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select each relief valve with sensing element that extends into storage tank.

1. Gas Water Heaters: ANSI Z21.22/CSA 4.4.
2. Oil-Fired Water Heaters: ASME rated and stamped and complying with ASME PTC 25.3.

E. Pressure Relief Valves: Include pressure setting less than working-pressure rating of water heater.

1. Gas Water Heaters: ANSI Z21.22/CSA 4.4.
2. Oil-Fired Water Heaters: ASME rated and stamped and complying with ASME PTC 25.3.

F. Drain Pans

1. Corrosion-resistant metal with raised edge. Provide dimensions not less than base of water heater and include drain outlet not less than NPS 3/4.

G. Piping Manifold Kits: Water heater manufacturer's factory-fabricated inlet and outlet piping arrangement for multiple-unit installation. Include piping and valves for field assembly that is capable of isolating each water heater and of providing balanced flow through each water heater.

H. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004.

2.3 SOURCE QUALITY CONTROL

A. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test commercial water heater storage tanks before shipment to minimum of one and one-half times pressure rating.

C. Prepare test reports.

PART 3 - EXECUTION

3.1 BOILER INSTALLATION

A. Install commercial boiler on concrete bases.

B. Install boiler level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

C. Install gas water heaters according to NFPA 54.

D. Install gas shutoff valves on gas supplies to gas water heaters without shutoff valves.

E. Install gas pressure regulators on gas supplies to gas water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.

F. Install automatic gas valves on gas supplies to gas water heaters, if required for operation of safety control.

G. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater, relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

H. Install thermometer on outlet piping of boiler.

I. Install pressure gage(s) on inlet and outlet piping of boiler piping.

3.2 CONNECTIONS

A. Install piping adjacent to boiler to allow service and maintenance. Arrange piping for easy removal of boiler.

B. Ground equipment according to Division 26.

C. Connect wiring according to Division 26.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boiler. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 52 16

SECTION 23 52 39 - PACKAGED FIRE-TUBE BOILERS (15 TO 100 HP)

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. These Specifications are intended to cover the furnishing of factory-assembled and tested fire-tube boiler unit**,** complete with all necessary accessories and auxiliaries including steel furnace, boiler and casing, refractory, insulation, boiler fittings and trim, burner equipment, combustion controls, instrumentation, electrical wiring, etc., as specified below or indicated on the accompanying drawings. The unit shall be furnished complete in all respects, ready for connecting to external services such as fuel, feedwater, electric, etc.

B. Required capacity, operating conditions and other criteria are specified in the Equipment Schedule.

1.2 SUBMITTALS

A. Submit shop drawings and product data in accordance with Section 23 05 00. Shop drawings shall include the following:

1. Boiler dimensions, including location of all connections and accessories.
2. Foundation dimensions, loadings, location of anchor bolts.
3. Detailed drawings of fuel train assemblies and individual components.
4. Schematic control drawings.
5. Electrical wiring diagram.
6. Control panel details, including internal piping and wiring.
7. Description of sequence of operation.
8. Complete bill of material listing all model numbers, sizes, etc.

B. Provide complete bound sets of operating and maintenance instructions. Include complete parts list and descriptive data for all components and appurtenances.

1.3 QUALITY ASSURANCE

A. Equipment Data Sheets:

1. The Contractor shall prepare and submit an Equipment Data Sheet covering the unit he proposes to furnish.
2. The Contractor shall also submit with his bid offer a drawing showing the general arrangement and dimensions of the unit and accessories which he proposes to furnish.

B. Certification: The boiler manufacturer shall submit to the Engineer a copy of manufacturer's data reports in accordance with the ASME Code for Power Boilers.

1.4 FM APPROVAL

A. The Contractor shall furnish to the Engineer, as soon as possible after receipt of purchase order, three (3) copies of all necessary and required certified drawings, bill of material, data and sequence of operation for OWNER to obtain approval from the Factory Mutual having jurisdiction. This is in addition to submission of shop drawings as specified under 1.07. Any items of equipment or design

not approved by FM shall be the complete responsibility of the Contractor. All labor and material required to comply with FM regulations shall be at the Contractor's expense, whether it be at the factory or on the job site.

1.5 WARRANTY

A. The Contractor shall warrant that the boiler unit is capable of continuous output at the specified rated capacity, pressure and temperature when supplied with makeup water, fuel, combustion air, etc., at the conditions specified. The boiler shall operate at the minimum overall efficiency specified at the above rated capacity and at optimum efficiencies over the entire modulation range.

B. Provide 5 year Par and Labor Burner Warranty.

PART 2 - PRODUCTS

2.1 ACCEPTACLE MANUFACTURERS

A. Hurst Boiler Co.

B. Cleaver Brooks.

2.2 BOILER

A. Boiler shall be steel, multiple pass horizontal fire-tube type designed, constructed and hydrostatically tested in accordance with the requirements of the Underwriter Laboratories, ASME Boiler Code, FM, GE Global for the working pressure specified.

B. The boiler shall be provided with adequate handholes, drum vent, front and rear bottom blowdown, surface blowdown, water column, safety valves and other connections as required by code.

C. The baffle chamber separating the furnace and fire doors shall be completely lined with conventional firebrick or firetile refractory materials and insulated. The flue gas outlet shall terminate in a collar for connection to the stack.

D. The front and rear flue doors shall be approved gastight and insulated. They shall be readily removable to permit access to all fire surfaces from both front and rear without removal of burner or control equipment. Doors shall be constructed of rigid material and suitably reinforced to withstand gas temperature. Doors shall be davit supported and have adjustable hinge design.

E. Unit shall be provided with minimum 2" thick mineral wool insulation. The boiler shall be lagged with a 22-gauge thick carbon steel jacket. The boiler jacket shall feature a bottom side primer of polyurethane resin base coat of .2 mil. Dry finish thickness and a final coat of .4 mil. dry finish thickness and a final coat of .8 mil. dry finish thickness of Valspar polyurethane resin based paint. The application of the paint is to be automated roller type and is to be oven dried. The exterior finish of the boiler jacket shall have a limited warranty by the manufacturer for five (5) years from date of installation for chalking, fade, peeling, or blistering.

F. The entire boiler base frame and other components shall be factory painted before shipment using a hard-finish enamel coating.

G. Boiler shall be mounted on a structural steel base, together with the mechanical draft fan and drive burner equipment, accessories and associated piping.

H. Required capacity, operating conditions, physical dimensions and other criteria are specified in the Equipment Schedule.

2.3 BOILER TRIM

A. Water Boiler Trim shall include a probe type low water cut off with manual reset, relief valve(s), with combination pressure gauge and thermometer, and operating and manual reset high limit aquastats.

B. Provide operating and proportioning boiler water temperature controls. Provide a high limit temperature control with a manual reset device.

C. Provide boiler safety relief valve(s) set a _____ psig.

D. Provide other boiler trim including (edit):

1. High pressure control with manual reset.
2. Boiler drain valve.
3. Automatic air vent valve, ¾”
4. Water pressure differential control.

2.4 BURNER EQUIPMENT

A. The combination burner shall be of the forced draft annular port flame retention type suitable for burning natural gas. The burner shall burn the specified quantity of fuel without objectionable vibrations, noise, or pulsation with no CO in the products of combustion. (The burner shall meet < ppm Nox while firing on natural gas utilizing flue gas recirculation technology). The burner shall be factory installed and wired, shall bear the listing mark of Underwriters Laboratories, Inc. evidencing compliance with requirements of UL-796 for gas burners and UL 296 for oil burners. The entire boiler and burner unit shall be factory fire tested prior to shipment with a copy of the fire test being supplied to the owner.

B. Burner Design

1. A burner fan shall furnish all combustion air, which shall be an integral part of the burner. The burner fan and motor shall be mounted below the horizontal centerline of the boiler for ease of maintenance and inspection. The burner air control louver shall be of the low-pressure drop, inlet type to allow visual checking of the louver settings, and ease of cleaning or adjustment. The burner shall have an air flow safety switch to prove combustion flow. The burner shall have an interrupted gas-electric ignition system with a 6,000-volt ignition transformer. An observation port shall be provided in the burner to provide observation of both the pilot and main flame.

C. Gas Pilot

1. The gas pilot shall be the premix type with automatic electric ignition, complete with electronic flame scanner to monitor the pilot so the primary fuel valve cannot open until pilot flame has been established. The gas pilot train is to consist of shut-off cock, pressure regulator, and automatic gas valve.

D. Gas Train

1. The main gas train shall be mounted on the boiler and shall include the following: A manually operated gas cock at the inlet to the train, a gas pressure reducing regulator, a motorized automatic gas valve, a second automatic gas valve, and a manually operated leak test cock located down stream from the automatic gas valve. The gas train shall include high and low gas pressure switches to monitor the gas pressure.

2.5 FLAME SAFEGUARD CONTROLS AND CONTROL PANEL

A. The Contractor shall provide a complete control system to provide for the automatic regulation of boiler pressure, combustion programming and combustion safeguards.

B. Flame Safeguard

1. Controller shall be computerized solid state having sequence and flame-on lights and digital "first out" fault code indications of flame safeguard trip functions. It shall include dynamic self-check logic. The controller shall have a fixed operating sequence incapable of being manually altered. The sequence shall include start, pre-purge, pilot and main fuel ignition run and post-purge cycles.
2. Controller shall be the non-recycle type for maximum safety that shall shutdown the burner and indicate as a minimum the following trip functions: pilot and main flame failure, high and low fire proving switch faults, running interlocks open, false flame signal and fuel valve open (when proof of closure switch is furnished).
3. The controller shall have a run/test switch. It shall allow interruptions to sequence just after pre- purge, during pilot ignition trial and run cycles for adjustments to firing rate motor, damper linkages and pilot flame for minimum turndown tests.

C. Control Panel

1. The control panel shall be mounted on the front door of the boiler in a location convenient to the operator. The hinged metal cabinet will have NEMA 1A rating that includes a neoprene dust seal and a Yale cabinet key type lock.
2. The panel shall contain the boiler flame safeguard controller, blower motor starter, indicating lights and selector switches.
3. The panel shall have a removable sub-base for mounting the flame safeguard controller, blower motor starter, and terminal blocks. For combination gas-oil and heavy oil fired boilers the panel will contain the fuel selector and/or oil heater selector switch.
4. The panel shall contain the following lights and switches:

   a. Lights
      - White - load demanded.
      - White - fuel valve open.
      - Red - low water.
      - Red - flame failure.

   b. Control Switches
      - Burner On-Off.
      - Manual-Automatic.
      - Manual Firing Rate Control.

D. Oil, heat and moisture resistant wire shall be used and identified with circuit numbers corresponding to the electrical wiring diagram.

E. All electrical equipment and wiring shall be in conformance with Underwriters Laboratories requirements.

F. Boiler to be supplied with a control circuit transformer and fuse protection for the control circuit.

G. Control Panel

1. The control panel shall be mounted on the front door of the boiler in a location convenient to the operator. The hinged metal cabinet will have NEMA 1A rating that includes a neoprene dust seal and a Yale cabinet key type lock.
2. The panel shall contain the boiler flame safeguard controller, indicating lights and selector switches.
3. Panel shall have a removable sub-base for mounting the flame safeguard controller, and terminal blocks.

H. Oil, heat, and moisture resistant wire shall be used and identified with circuit numbers corresponding to the electrical wiring diagram.

I. All electrical equipment and wiring shall be in conformance with Underwriters Laboratories requirements.

J. Boiler to be supplied with a control circuit transformer and fuse protection for the control circuit.

K. Provide an interface to connect Boiler Control Panel to Building Automation System for Enable-Disable and alarm notification.

2.6 ELECTRICAL REQUIREMENTS

A. Design:

1. Provide all components necessary for a complete electrical system.
2. In general, electrical components shall be installed in a boiler panel with the exception of such items as pressure switches, level controls, etc., which must be externally mounted because of functional necessity. All selector switches, including the fuel selector switch, shall be installed in the panel. Control components shall be of the proper type and construction for the locations in which they are to be placed. Components which are commercially available for panel mounting shall be of the open type and shall be installed so as to be easily accessible.
3. The entire electrical system shall be pre-wired at the factory with all components wired to terminal strips in the panel enclosure. All wires shall be returned to the terminal strip from each connection limit switches or other devices. Wiring inside of the panel shall be contained in raceways and wiring to components mounted on panel door shall be properly harnessed.
4. Mount terminal strips adjacent to the side of the panel and boiler terminal box and mark each terminal clearly and permanently. Provide 10 percent additional spare terminals. Arrange internal and external wiring connections to avoid crossing over the terminal strips. Connect not more than 3 wires to one side of a terminal. Connectors shall be of the pressure crimp type. Plain wires installed under screw heads are not acceptable.
5. Identify each wiring terminal and component to correspond with the symbols in wiring diagram. Color codes all wiring. Mount laminated plastic name tags adjacent to each

component and device.

6. The control voltage for all electrical control components shall be 115 volt, single phase, 60 hertz and shall be obtained from a control transformer provided in the panel. Where lower voltages are required for electronic subassemblies, they shall be obtained from transformers with isolated secondary windings.

B. Enclosures: Control enclosures shall be non-ventilated NEMA 12 design with hinged door and hand tool opened latches.

C. Control Transformers: Main control circuit transformers shall be a 230/460 volt primary and an isolated 120 volt secondary with one side protected by a circuit breaker and the other side grounded. Transformers having a capacity of 25% in excess of the connected load shall be provided.

D. Operator Devices: Push buttons, indicating lights and selector switch operators shall be of the oiltight type, Cutler Hammer. Indicating lights shall be of the "push-to-test" transformer type for 120 volt primary power.

E. Motor Starters: Each automatically controlled motor shall have a magnetic starter suitable for full voltage, non-reversing, 600 volt service, with overload protection in each leg. Contactor coil shall be rated for 120 volts. Each starter shall be furnished with spare normally open or closed auxiliary contact.

2.7 FACTORY TESTS

A. After the unit is completely fabricated and assembled, it shall be given the following tests:

1. Hydrostatic test in accordance with the requirements of the A.S.M.E. Boiler Code. Test shall be witnessed and certified by a National Board Inspector.
2. All controls, circuits, etc., to be tested for continuity and functional capability.
3. If any oil or grease is used during fabrication so that the water side of the boiler could be contaminated, the boiler shall be "boiled out". Boil out procedure shall be repeated until all indication of contamination is removed.
4. Fire test shall consist of actual firing of unit with fuels specified and an operational check of all operating controls, safety valves, all limiting devices, etc. Test shall be documented and a full report given to the ARCHITECT.

2.8 START-UP SERVICE

A. When the boiler has been completely installed, the Contractor shall arrange for a factory trained specialist to put the boiler into service, which shall include assisting in a field hydrostatic test and the adjusting of the burner and control system.

2.9 PERFORMANCE TESTS

A. After completion of the boiler installation and at a time to be mutually agreed upon between the Contractor and the Architect, a performance test shall be conducted on the boiler and firing equipment to determine that the boiler is capable of continuous operation at the ratings specified, that the burners and controls will function as specified under all load conditions, and that manufacturer's guarantee of efficiency, steam quality, etc. have been met.

B. Except as modified herein, standard short form tests in accordance with the latest revision of the A.S.M.E. Power Test Code shall be performed. The test shall consist of a run of approximately one hour at 20 percent of maximum continuous rating; a run of one hour at 50 percent of maximum continuous rating; and a run of two hours at 100 percent of maximum continuous rating when firing each of the fuels specified.

C. The Contractor shall furnish all special instruments and equipment required to properly conduct the above boiler tests, and shall furnish the services of a factory-trained technician for the full duration of these tests. He shall conduct all necessary preliminary tests and make all necessary adjustments to the equipment before the formal testing is begun.

D. Fuel, water and electricity will be furnished by Owner.

E. The time and date of the test, all "Items of Agreement" required by the A.S.M.E. Power Test Code, or any proposed deviation from the procedure specified herein shall be mutually agreed upon in advance between the Contractor and the Architect.

F. During the boiler efficiency tests, the manufacturer's guarantees of efficiency when burning the specified fuels shall be clearly demonstrated. Certified copies of the test log shall be submitted to the Architect after completion of the tests.

G. Tests shall also establish that maximum gas firing rate shall be attained with not over 10% excess air. When firing oil, the excess air shall not exceed 12-1/2% at maximum firing rate. The modulated firing range shall not be less than specified on either fuel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Boiler accessories, such as safety valves, water column and main gas train piping, may be shipped loose for field assembly to the boiler. Mount and connect all loose accessory equipment on the boiler.

B. Furnish and install all miscellaneous piping, fittings, and shutoff valves required to complete the boiler installation in accordance with the drawings.

C. Install boiler flue stack and relief cap.

D. Insulate boiler piping and stack as specified under Section 23 07 00 of this specification.

E. Start-up Service

1. After boiler installation is completed; the manufacturer shall provide the services of a field representative for starting the unit and training the operator at no additional costs. A factory approved and authorized start-up report shall be submitted to the customer/user at the time of start-up.

3.2 TESTS

A. A representative of the manufacturer shall perform the following tests:

1. Input capacity.
2. Net stack temperature.
3. Oxygen content.
4. Carbon dioxide content.
5. Carbon monoxide content.
6. Fuel to water efficiency.

B. Submit final test report to Engineer.

C. The boiler must be guaranteed to operate at a minimum efficiency of 82 percent at 100 percent of rating when burning natural gas.

END OF SECTION 23 52 39

SECTION 23 64 16 - CENTRIFUGAL WATER CHILLERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Factory Built Water Cooled Centrifugal Chiller.

B. Integral Unit Controls and Control Panel.

C. Solid State Motor Starter and/or Variable Frequency Drive (VFD).

D. Internal Piping and Wiring.

E. Operating Charge of Refrigerant and Oil.

F. Refrigerant Monitoring/Leak Detection Systems.

G. Training.

1.2 SUBMITTALS

A. Submit shop drawings and manufacturer's product data including the following:

1. Dimensional data.
2. Materials of construction.
3. Piping connection location and sizes.
4. Auxiliary piping, valves, strainers.
5. Power and control wiring diagrams.
6. Installation and assembly instructions.
7. Weights and loadings.
8. Foundation requirements.
9. Required and recommended clearances.
10. Interconnecting piping diagrams.

B. Submit copies of all lubricating oil sample test reports.

C. Submit performance test report for review not fewer than 7 days prior to shipment of chiller. Testing shall include: (1) full load testing as well as (2) IPLV/NPLV testing.

D. Submit performance test certification letter for review not fewer than 7 days prior to shipment of chiller.

E. Submit maintenance and operations manual including, but not limited to start-up instructions, maintenance data, parts lists, trouble shooting guide, control diagrams, and recommended preventive maintenance schedule.

F. Submit acoustical data for review not fewer than 7 days prior to submittal of bid. Unless otherwise indicated, maximum chiller sound output shall be in accordance with ARI 575-87 Method of Measuring Machinery Sound within Equipment Rooms. Refer to equipment schedule and contract

documents for project specific acoustical requirements. Manufacturer shall certify compliance with OSHA sound requirements.

1.3 QUALITY ASSURANCE

A. Test and rate chillers in accordance with methods prescribed by ARI Standard 550/590-98. Chiller testing shall be performed on an ARI certified test stand with qualified operating staff. Testing may be performed at the manufacturer's chiller fabrication facility or at an independent third party test facility as necessary.

B. Provide a letter signed by an corporate officer of the manufacturer certifying that the product has been tested as required by ARI Standard 550/590-98 and complies with the requirements of the Standard.

1.4 WARRANTY

A. Provide a "Bumper to Bumper" warranty covering all parts and labor for the entire chiller (NO ITEM EXCLUDED) including the starter(s) and/or VFD(s) for five (5) years from the date of start-up. Warranty shall provide for replacement of refrigerant for five (5) years from the date of start-up. Warranty shall include parts and labor to the job site.

B. Manufacturer shall provide an oil analysis at start up and at oil changes performed at manufacturer-recommended intervals to establish oil base line. An additional oil analysis shall be performed and furnished to the owner annually at the end of each operational year

1.5 MAINTENANCE

A. Chiller maintenance shall be the responsibility of the owner except as follows:

1. The manufacturer shall provide recommended chiller purge services to maintain operational efficiency within the warranty period.
2. The manufacturer shall provide any necessary maintenance on the purge equipment during the warranty period.
3. The manufacturer shall change the chiller oil at manufacturer-recommended service intervals and/or as determined to be necessary from annual oil analysis.
4. The manufacturer shall provide additional refrigerant as necessary to compensate for losses during purge cycles to ensure that chiller is operating at scheduled performance levels.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Carrier.

B. Daikin Applied.

C. Trane.

2.2 COMPRESSOR

A. Compressor shall be single or multi-staged, hermetic centrifugal type.

B. Impellers shall be high strength aluminum alloy, balanced both statically and dynamically.

C. Compressor assembly shall be run-tested at the factory. Vibration shall not exceed 0.8 mil at the compressor housing.

D. Impeller shall be proof-tested at least 15 percent above design operating speed.

E. Automatic capacity reduction shall be provided using inlet guide vanes. The chiller shall be capable of stable operation to ten percent of full load with standard ARI entering condensing water relief without hot gas bypass.

2.3 LUBRICATION SYSTEM

A. A positive displacement submerged oil pump shall provide lubrication to all parts requiring oil. Provisions shall be included for controlled heating of oil. Heater shall be selected to maintain oil at sufficient level to minimize affinity for refrigerant. Piping, power and control wiring and control devices shall be factory installed.

B. Oil cooling shall be water-cooled and thermostatically controlled. This shall be an integral cooling system. Coolers located inside the evaporator or condensers are not acceptable. The manufacturer shall provide all necessary piping, valves and controls at the factory.

C. The initial refrigerant and oil charges shall be furnished and installed by the chiller manufacturer in sufficient quantities to fully charge the system and to leave it in complete and satisfactory operating condition. All or any part of the refrigerant or oil charge that may be lost during the testing operations and/or during the period of the warranty shall be replaced by the chiller manufacturer under this Section of the Specifications without additional cost to the Owner. The refrigerant and oil installed in the chiller shall be measured by weight.

D. Provide an external replaceable oil filter with provisions for servicing without removing the unit refrigerant charge. The lubrication oil filter shall be equipped with a differential pressure gauge. The water chilling manufacturer shall submit the normal differential pressure at which the oil filter should be replaced. The initial oil filter shall be replaced by the Contractor after a maximum 100 hours of operation or less if recommended by the chiller manufacturer. The chiller manufacturer shall affix a permanent tag to the area near the point of oil filter change which states the type of oil shipped in the machine.

E. Design lubrication system to ensure adequate lubrication prior to starting, coast down and normal operation.

F. The refrigerant circuit shall be complete with a factory installed refrigerant filter drier system complete with replaceable core filter driers, moisture/sight glass indicators, valves, and associated piping.

2.4 MOTOR

A. Motor shall be a hermetic squirrel cage induction type of sufficient size to efficiently fulfill

compressor horsepower requirements. Motor shall be liquid refrigerant cooled with internal thermal overload protection devices embedded in the winding of each phase. Motor shall be compatible with the starting method specified hereinafter. . Motor shall be designed and terminals furnished, to permit connection to the starter or variable frequency drive. Open drive style motors are prohibited.

B. Motor full-load amperes (FLA) at design conditions shall not exceed motor nameplate FLA.

2.5 STARTERS

A. Where indicated on the equipment schedule or as otherwise indicated on the contract documents, provide chiller(s) with solid state starter(s) furnished by the chiller manufacturer. The chiller motor starter(s) shall be solid state type and either unit mounted or remotely mounted as scheduled or as otherwise indicated on the contract documents. If remotely mounted starter is provided, the chiller manufacturer shall provide all field connection wiring to connect the chiller to the starter. If starter is not within view of the power distribution panel, the starter shall be complete with separate disconnect switch in lockable NEMA 1 enclosure. Starters of the wye-delta, autotransformer, or across the line type are prohibited.

B. Unless indicated otherwise on the drawings, starter shall be rated for the voltage indicated on the drawings, 3 phase, 3-wire plus ground, 60 Hz solid-state type. Power supplies for all auxiliary devices such as control power, oil pump, oil heater, purge compressor, purge heater, and pump-out compressor shall be developed within the three-phase compressor motor starter. Each separate power supply shall be fused on both the primary and secondary side of the transformer. If power requirements are the same as main line power then this branch circuit shall also be used. If more than one auxiliary power supply is required, then all auxiliary power supplies shall be equipped with a disconnecting means in the form of fused disconnect or circuit breaker. Auxiliary power supplies from sources outside the starter are not acceptable.

C. Starter shall be enclosed in a unit mounted NEMA 1 enclosure.

D. Starter to be furnished with the following accessories:

1. Current transformer and three phase current digital display.
2. 3-phase voltmeter with a digital display switch.
3. Control power transformer to provide 115-1-60 power for the chiller controls.
4. Elapsed time meter for each compressor.
5. Electrical lugs for connection to incoming copper power connections.
6. Power factor correction capacitors so that power factor at design load is not less than 0.95.

E. Starter shall incorporate the following protection features:

1. Three phase, phase failure/phase reversal protection.
2. Phase unbalance.
3. Overvoltage.
4. Undervoltage.
5. Ground fault.
6. Stall protection.

F. Starter shall be provided with magnetic or electronic overload protection.

G. The starter shall incorporate the following digital display features:

1. Motor current for each phase.
2. % motor current of rated load amps for each phase.
3. Number of motor starts.
4. Voltmeter.
5. Megawatts.
6. Power factor.
7. Megavars.
8. Megawatt demand.
9. Megawatt hour meter.
10. Frequency.
11. Total elapsed run time.
12. Instantaneous overcurrent trip.
13. Underload trip.
14. Phase unbalance/reversal trip.
15. Over/under voltage trip.
16. Rotor high temperature trip.

2.6 VARIABLE FREQUENCY DRIVES (VFD)

A. Where indicated on the equipment schedule or as otherwise indicated on the contract documents, provide chiller(s) with variable frequency drive(s) furnished by the chiller manufacturer. The chiller variable frequency drive(s) shall be either unit mounted or remotely mounted as scheduled or as otherwise indicated on the contract documents. If remotely mounted VFD is provided, the chiller manufacturer shall provide all field connection wiring to connect the chiller to the VFD. If the VFD is not within view of the power distribution panel, the VFD shall be equipped with an integral disconnect means. VFD shall be provided in a NEMA type 1 enclosure.

B. VFD(s) shall have 110% continuous overload of continuous amp rating with no time limit, PWM (pulse width modulated) output, IGBT (insulated gate bipolar transistors) power technology, full power rating at 2kHz, DC bus inductor (choke), and wireless construction.

C. VFDs above 275 amps shall be water-cooled, those below may be air-cooled. Heat producing devices within VFD shall be contained in a single heat sink with single inlet and out connections for the connection of chilled water. When factory mounted on the chiller package, the water connections shall be piped and leak tested at the factory.

2.7 EVAPORATORS AND CONDENSERS

A. Provide shell and tube type evaporators, condensers (and marine heads, where indicated) designed in accordance with the requirements of the latest edition of the ASME code for unfired pressure vessels and bearing the ASME stamp. Use welded steel shells, and copper tubes with integral fins, rolled or silver brazed into tube sheets. Each tube shall be integral externally finned 3/4 inch nominal diameter seamless copper. Tube wall thickness shall be minimum 0.025 inch wall thickness at the finned section and 0.045 inch wall thickness at the smooth ends. Water velocity shall be between 4 and 6 feet per second. Tubes shall be individually replaceable with tube ends rolled into annular grooves in the tube sheets. In evaporators, provide refrigerant chambers with adequate space or baffles to distribute entering liquid and separate liquid from leaving gas. In condensers provide baffles to ensure even distribution of incoming gas and to concentrate non-condensable gases.

B. Where scheduled and/or shown on the contract documents, provide welded steel marine type water boxes on both ends of condenser and evaporator to permit inspection of tubes from either end without disturbing the water piping. Water boxes shall be tapped for drains and vent connections. Provide cast iron or shaped steel heads on both ends of evaporator and condenser with tapped drain, vent and lifting eye connections. Heads shall be easily removable to permit inspection or replacement of tubes.

C. Where scheduled and/or shown on the contract documents, provide anodes in condenser water circuits. Anodes shall be installed through two inch threaded ports in ends of marine water boxes.

D. Design water side of evaporators and condenser for 150 psi working pressure and test at not less than 1.5 times maximum working pressure. The waterside of each heat exchanger shall be designed, constructed, tested, and stamped in accordance with ASME Section VIII.

E. Design refrigerant to water and water-to-water transfer surfaces with waterside fouling factors at 0.0001 for evaporator, and for 0.00025 for condenser unless scheduled otherwise on contract documents.

F. Test refrigerant side at not less than 1.5 times maximum working pressure and not less than 30 psi.

G. Refrigerant flow control devices shall be factory installed and piped. Refrigerant flow control devices shall be either electronic or thermal expansion valve type only; fixed orifice or float type devices are prohibited.

H. Relief devices shall be provided for the refrigerant side, in accordance with ANSI B9.1 Safety Code and local codes. Relief devices shall consist of a frangible carbon bursting disc relief device located in the compressor suction line and a self closing refrigerant pressure relief located in the refrigerant relief vent pipe. In addition, a remotely monitored refrigerant leak detector shall be installed between the two devices. Multiple relief devices for each chiller shall be brought to a common vent connection for each chiller to safely discharge outdoors. Flexible connectors shall be installed at all points of connection of refrigerant reliefs to the chiller. There shall be one individual refrigerant relief pipe per chiller, sized to the requirements of applicable codes run to the outside of the building. Each refrigerant relief pipe must include a cleanable, vertical-leg dirt trap to catch vent-stack condensation.

I. Provide isolation valves, check valves and service valves to permit isolation of the refrigerant in the condenser or receiver and allow for pump-out of refrigerant for service without discharge to atmosphere. Where condenser barrel cannot be utilized for storage of refrigerant during service, provide pump-down storage tank, sized as required to store full refrigerant charge. Coordinate location and size of storage tank 7 days prior to bid.

J. Provide anodes in condenser water circuits. Anodes shall be installed through two inch threaded ports in ends of marine water boxes.

2.8 INSULATION

A. The evaporator, compressor suction piping and other low temperature refrigerant piping shall be factory insulated with flexible closed-cell plastic type insulation.

B. Insulation shall be minimum 3/4 inch thick.

C. All noise radiating components which radiate levels in excess of 75 dbA PWL shall be enclosed in a noise barrier jacket provided by the manufacturer of the chillers.

2.9 REFRIGERANTS

A. Chillers using R-134a or R-123 are acceptable.

2.10 GRAPHIC CONTROL CENTER

A. Each unit shall be furnished with a complete electronic control center in a lockable enclosure, factory-mounted, piped and wired. Control system shall be interfaced to the Andover building energy management/control system (EMCS) through discrete I/O interface (analog and digital inputs or outputs). Open protocol DDC interface card if supplied in addition to discrete I/O interface shall be compatible with Andover building energy management control system (EMCS).

B. The capacity, operating and safety controls, and control sequence, shall be designed for completely fail-safe automatic operation. The control sequence shall provide for operation of the oil pump prior to energizing the compressor motor and during normal coast-down. The sequence shall prevent recycling of the unit prior to a predetermined safe time interval.

C. Furnish a solid state electronic capacity control system. Provision shall be made in the control center for interlocking of compressor motor starter or VFD, chilled water flow switch, condenser water pump and cooling tower fan. The control center shall contain the following:

1. Chilled water temperature controller with control point adjustment.
2. Motor current controller with automatic load adjustment.
3. Motor current controller with automatic load limiting selector switch for 40% to 100% full load amperes.
4. Compressor start-stop switch with reset pushbutton and operating signal light.
5. All necessary components to permit automatic start-up from a remote contact closure.
6. Manual reset protective controls with indication of high discharge temperature, high motor temperature, high and low refrigerant temperature or pressure, low oil pressure and power failure.
7. Refrigerant evaporator and condenser pressure, and oil pressure indication.
8. Purge unit excess purge indication with reset button and/or refrigerant transfer unit power switch.
9. Terminal strip clearly marked for field wiring.
10. Digital display of evaporator entering and leaving water temperatures, condenser entering and leaving water temperatures, super heat, and percent rated load amps and amps.

D. The chiller leaving water temperature controller and demand limit control shall have the capability of remote reset from an external 4-20 mA or 0-10Vdc signal. A selector switch shall be located on the control panel to enable "local chiller control" or "auto reset control" to be selected.

E. The chiller controls shall be provided with parallel chiller operation capability to equalize the capacity of each chiller when two or more are in operation.

F. The chiller shall restart automatically after power failure.

G. The chiller manufacturer shall provide open protocol for the temperature control company. The chiller manufacturer shall provide the following monitoring points:

1. Entering and leaving evaporator water temperature.
2. Entering and leaving condenser water temperature.
3. Refrigerant temperatures and pressures as follows:

    a. Evaporator.
    b. Suction line.
    c. Superheat.
    d. Discharge.
    e. Condenser.
    f. Approach.
    g. Oil.

4. Motor current and motor percent RLA.
5. Operating hours.
6. Number of starts.

H. The chiller manufacturer shall provide the temperature control company the ability to change the following setpoints:

1. Unit status-start/stop/clear fault.
2. Leaving and rest evaporator setpoint.
3. Manual amp limit.

2.11 REFRIGERANT LEAK DETECTION

A. Chiller manufacturer shall provide the necessary monitoring equipment to comply with ASHRAE 15-1992. See specification section 23 64 27 - REFRIGERANT MONITORING AND SAFETY EQUIPMENT for exact requirements.

2.12 PAINTING

A. The manufacturer shall remove all rust, scale, and oil from the chiller prior to applying two coats of rust inhibitive primer plus two coats of factory applied industrial machinery enamel to all ferrous parts prior to shipment.

2.13 ANCILLARY SYSTEMS

A. Purge System (negative pressure chillers only):

1. The chiller manufacturer shall provide a separate high efficiency purge system that operates independently of the unit and can be operated while the unit is off. The system shall consist of an air-cooled condensing unit, purge condensing tank, pumpout compressor and control system.
2. A dedicated condensing unit shall be provided with the purge system to provide a cooling source whether or not the chiller is running. The condensing unit shall provide a low purge coil temperature to result in a maximum loss of 0.1 pounds of refrigerant per pound of purged air.
3. The purge tank shall consist of a cooling coil, filter-drier cores, water separation tube, sight glass, drain, and air discharge port. Air and water are separated from the refrigerant vapor and accumulated in the purge tank.

4. The pumpout system shall consist of a small compressor and a restriction device located at the pumpout compressor suction connection.
5. The purge unit shall be connected to a 100% reclaim device.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Adjust chiller in alignment on concrete foundations.

B. All gauge and control piping and wiring within the confines of the machine base shall be complete.

C. Connect piping between refrigerant transfer unit and chiller if required.

D. Route refrigerant relief discharge to the exterior of the building.

E. Provide additional insulation, if required, to prevent condensation.

3.2 START-UP

A. Supply initial charge of refrigerant and oil.

B. The chiller manufacturer shall furnish the services of a factory-trained specialist to supervise the unit assembly, pressure testing, leak testing, charging evacuation, the checkout of the interlock wiring, and the start-up of the units. The water chilling unit manufacturer shall certify in writing that this Work was supervised and approved. In addition, the factory-trained specialist shall also instruct the Owner's operating personnel in the operation and service of the units for a period of one week, based on a forty-hour week, excluding nights, weekends, and travel time to and from the Project. Schedule training with the Owner. Provide proper coordination with the contractor on startup of the cooling towers, condenser water pumps and chilled water pumps.

END OF SECTION 23 64 16

SECTION 23 64 17 - MAGNETIC BEARING CENTRIFUGAL WATER CHILLERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Factory Built Water Cooled Magnetic Bearing Centrifugal Chiller.

B. Integral Unit Controls and Control Panel.

C. Motor with integral Variable Frequency Drive (VFD).

D. Internal Piping and Wiring.

E. Operating Charge of Refrigerant.

F. Refrigerant Monitoring/Leak Detection Systems.

G. Training.

1.2 SUBMITTALS

A. Submit shop drawings and manufacturer's product data including the following:

1. Dimensional data.
2. Materials of construction.
3. Piping connection location and sizes.
4. Auxiliary piping, valves, strainers.
5. Power and control wiring diagrams.
6. Installation and assembly instructions.
7. Weights and loadings.
8. Foundation requirements.
9. Required and recommended clearances.
10. Interconnecting piping diagrams.

B. Submit performance test report for review not less than 7 days prior to shipment of chiller. Testing shall include: (1) full load testing as well as (2) IPLV/NPLV testing.

C. Submit performance test certification letter for review not less than 7 days prior to shipment of chiller.

D. Submit maintenance and operations manual including, but not limited to start-up instructions, maintenance data, parts lists, trouble shooting guide, control diagrams, and recommended preventive maintenance schedule.

E. Submit acoustical data for review not less than 7 days prior to submittal of bid. Unless otherwise indicated, maximum chiller sound output shall be in accordance with ARI 575-87 Method of Measuring Machinery Sound within Equipment Rooms. Refer to equipment schedule and contract documents for project specific acoustical requirements. Manufacturer shall certify compliance with OSHA sound requirements.

1.3 QUALITY ASSURANCE

A. Test and rate the chillers in accordance with methods prescribed by ARI Standard 550/590-98. Chiller testing shall be performed on an ARI certified test stand with qualified operating staff. Testing may be performed at the manufacturer's chiller fabrication facility or at an independent third party test facility as necessary.

B. The requirement for witness testing of the chillers by the Owner and/or the Engineer shall be determined prior to bidding and included as a separate line item with the chiller pricing Witness testing shall include transportation, lodging and meal cost for a total of 2 (two) owner representatives. The Contractor shall notify the Owner and/or the Engineer in writing of the production schedule; the date of the chiller testing shall be determined by the factory production schedules. Refer to the equipment schedules on the contract document for requirement for witness testing of chillers. Where witness testing is indicated, requirement for submittal of test data and final test report 7 days prior to shipment is hereby omitted.

C. Provide a letter signed by a corporate officer of the manufacturer certifying that the product has been tested as required by ARI Standard 550/590-98 and complies with the requirements of the Standard.

1.4 WARRANTY

A. Provide a "Bumper to Bumper" warranty covering all parts and labor for the entire chiller (NO ITEM EXCLUDED) including the starter(s) and/or VFD(s) for five (5) years from the date of start-up. Warranty shall provide for replacement of refrigerant for five (5) years from the date of start-up. Warranty shall include parts and labor to the job site.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Daikin Applied.

2.2 MAGNETIC BEARING COMPRESSORS

A. Compressors shall be a unitized motor and compressor assembly with variable frequency drive speed control and utilizing magnetic levitation bearings as manufactured by Danfoss.

B. Motor component shall permanent-magnet, synchronous motor of the hermetic type, of sufficient size to efficiently fulfill compressor horsepower requirements. Motor shall be liquid refrigerant cooled with internal thermal overload protection devices embedded in the winding of each phase. Motor shall be compatible with variable frequency drive operation.

C. Compressor shall be shall be two-stage, oil-free, magnetic bearing, hermetic, centrifugal type.

D. Each compressor shall have variable frequency drive operating in concert with inlet guide vanes for optimized unit part load efficiency.

E. The compressor drive train shall be capable of coming to a controlled, safe stop in the event of a power failure.

F. The evaporator, condenser, and expansion valve shall be common to each of the compressors. The chiller shall be capable of running on one compressor with the other compressor or any of its auxiliaries inoperable or removed.

G. The chiller shall be capable of stable operation to ten percent of full load with standard ARI entering condensing water relief without hot gas bypass.

2.3 EVAPORATORS AND CONDENSERS

A. Provide shell and tube type evaporators, condensers (and marine heads, where indicated) designed in accordance with the requirements of the latest edition of the ASME code for unfired pressure vessels and bearing the ASME stamp. Use welded steel shells, and copper tubes with integral fins, rolled or silver brazed into tube sheets. Each tube shall be integral externally finned 3/4 inch nominal diameter seamless copper. Tube wall thickness shall be minimum 0.025 inch wall thickness at the finned section and 0.045 inch wall thickness at the smooth ends. Water velocity shall be between 4 and 6 feet per second. Tubes shall be individually replaceable with tube ends rolled into annular grooves in the tube sheets. In evaporators, provide refrigerant chambers with adequate space or baffles to distribute entering liquid and separate liquid from leaving gas. In condensers provide baffles to ensure even distribution of incoming gas and to concentrate non-condensable gases.

B. Where scheduled and/or shown on the contract documents, provide welded steel marine type water boxes on both ends of condenser and evaporator to permit inspection of tubes from either end without disturbing the water piping. Water boxes shall be tapped for drains and vent connections. Provide cast iron or shaped steel heads on both ends of evaporator and condenser with tapped drain, vent and lifting eye connections. Heads shall be easily removable to permit inspection or replacement of tubes.

C. Where scheduled and/or shown on the contract documents, provide anodes in condenser water circuits. Anodes shall be installed through two inch threaded ports in ends of marine water boxes.

D. Design water side of evaporators and condenser for 150 psi working pressure and test at not less than 1.5 times maximum working pressure. The waterside of each heat exchanger shall be designed, constructed, tested, and stamped in accordance with ASME Section VIII.

E. Design refrigerant to water and water to water transfer surfaces with waterside fouling factors at 0.0001 for evaporator, and for 0.00025 for condenser unless scheduled otherwise on contract documents.

F. Test refrigerant side at not less than 1.5 times maximum working pressure and not less than 30 psi.

G. Refrigerant flow control devices shall be factory installed and piped. Refrigerant flow control devices shall be either electronic expansion valve type only; fixed orifice or float type devices are prohibited.

H. Relief devices shall be provided for the refrigerant side, in accordance with ANSI B9.1 Safety Code and local codes. Relief devices shall consist of a frangible carbon bursting disc relief device located in the compressor suction line and a self closing refrigerant pressure relief located in the refrigerant relief vent pipe. In addition, a remotely monitored refrigerant leak detector shall be installed between the two devices. Multiple relief devices for each chiller shall be brought to a common vent connection for each chiller to safely discharge outdoors. Flexible connectors shall be installed at all points of connection of refrigerant reliefs to the chiller. There shall be one individual refrigerant relief pipe per chiller, sized to the requirements of applicable codes run to the outside of the building.

Each refrigerant relief pipe must include a cleanable, vertical-leg dirt trap to catch vent-stack condensation.

I. Provide isolation valves, check valves and service valves to permit isolation of the refrigerant in the condenser or receiver and allow for pump-out of refrigerant for service without discharge to atmosphere.

J. Provide anodes in condenser water circuits. Anodes shall be installed through two inch threaded ports in ends of shaped heads.

2.4 INSULATION

A. The evaporator, compressor suction piping and other low temperature refrigerant piping shall be factory insulated with flexible closed-cell plastic type insulation.

B. Insulation shall be minimum 3/4 inch thick.

C. All noise radiating components which radiate levels in excess of 75 dbA PWL shall be enclosed in a noise barrier jacket provided by the manufacturer of the chillers.

2.5 REFRIGERANTS

A. Chillers using R-134a are acceptable.

2.6 GRAPHIC CONTROL CENTER

A. Each unit shall be furnished with a complete electronic control center in a lockable enclosure, factory-mounted, piped and wired. Control system shall be interfaced to the building energy management/control system. Refer to the equipment schedule and the contract documents to identify the type building energy management/control system (EMCS) used at project site. Provide chiller with communication card compatible with building EMCS.

B. The capacity, operating and safety controls, and control sequence, shall be designed for completely fail-safe automatic operation. The sequence shall prevent recycling of the unit prior to a predetermined safe time interval.

C. Furnish a solid state electronic capacity control system. Provision shall be made in the control center for interlocking of compressor motor VFD, chilled water flow switch, condenser water pump and cooling tower fan. The control center shall contain the following:

1. Chilled water temperature controller with control point adjustment.
2. Motor current controller with automatic load adjustment.
3. Motor current controller with automatic load limiting selector switch for 40% to 100% full load amperes.
4. Compressor start-stop switch with reset pushbutton and operating signal light.
5. All necessary components to permit automatic start-up from a remote contact closure.
6. Manual reset protective controls with indication of high discharge temperature, high motor temperature, high and low refrigerant temperature or pressure, low oil pressure and power failure.
7. Refrigerant evaporator and condenser pressure indication.
8. Purge unit excess purge indication with reset button and/or refrigerant transfer unit power

switch.

9. Terminal strip clearly marked for field wiring.
10. Digital display of evaporator entering and leaving water temperatures, condenser entering and leaving water temperatures, super heat, and percent rated load amps and amps.

D. The chiller leaving water temperature controller and demand limit control shall have the capability of remote reset from an external 4-20 mA signal. A selector switch shall be located on the control panel to enable "local chiller control" or "auto reset control" to be selected.

E. The chiller controls shall be provided with parallel chiller operation capability to equalize the capacity of each chiller when two or more are in operation.

F. The chiller shall restart automatically after power failure.

G. The chiller manufacturer shall provide open protocol for the temperature control company. The chiller manufacturer shall provide the following monitoring points:

1. Entering and leaving evaporator water temperature.
2. Entering and leaving condenser water temperature.
3. Refrigerant temperatures and pressures as follows:

    a. Evaporator.
    b. Suction line.
    c. Superheat.
    d. Discharge.
    e. Condenser.
    f. Approach.

4. Motor current and motor percent RLA.
5. Operating hours.
6. Number of starts.

H. The chiller manufacturer shall provide the temperature control company the ability to change the following setpoints:

1. Unit status-start/stop/clear fault.
2. Leaving and rest evaporator setpoint.
3. Manual amp limit.

2.7 REFRIGERANT LEAK DETECTION

A. Chiller manufacturer shall provide the necessary monitoring equipment to comply with ASHRAE 15-1992. See specification section 15635 - REFRIGERANT MONITORING AND SAFETY EQUIPMENT for exact requirements.

2.8 PAINTING

A. The manufacturer shall remove all rust, scale, and oil from the chiller prior to applying two coats of rust inhibitive primer plus two coats of factory applied industrial machinery enamel to all ferrous parts prior to shipment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Adjust chiller in alignment on concrete foundations.

B. All gauge and control piping and wiring within the confines of the machine base shall be complete.

C. Connect piping between refrigerant transfer unit and chiller if required.

D. Route refrigerant relief discharge to the exterior of the building.

E. Provide additional insulation, if required, to prevent condensation.

3.2 START-UP

A. Supply initial charge of refrigerant.

B. The chiller manufacturer shall furnish the services of a factory-trained specialist to supervise the unit assembly, pressure testing, leak testing, charging evacuation, the checkout of the interlock wiring, and the start-up of the units. The water chilling unit manufacturer shall certify in writing that this Work was supervised and approved. In addition, the factory-trained specialist shall also instruct the Owner's operating personnel in the operation and service of the units for a period of one week, based on a forty-hour week, excluding nights, weekends, and travel time to and from the Project. Schedule training with the Owner. Provide proper coordination with the contractor on startup of the cooling towers, condenser water pumps and chilled water pumps.

END OF SECTION 23 64 17

SECTION 23 64 23 - AIR COOLED CHILLERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Air Cooled Packaged Chillers.

B. Change of Refrigerant and Oil.

C. Start-Up Services.

1.2 SYSTEM DESCRIPTION

A. Each packaged liquid chiller shall be completely factory assembled including all interconnecting refrigerant piping and internal wiring of controls and motor starting equipment. The unit shall be shipped with operating refrigerant charge. Provide a single electrical point of connection with lugs for landing power wires.

B. Provide each refrigerant circuit with hot gas muffler, moisture indicating sight glass, filter drier, thermal expansion valve and charging valves.

C. Insulate suction line with close-fitting closed cell foam plastic vapor barrier insulation.

1.3 SUBMITTALS

A. Submit manufacturer's product data including:

1. Dimensional and weight data.
2. Capacities. ARI certified selection at actual conditions and standard ARI conditions.
3. Water pressure drops.
4. Electrical characteristics.
5. Materials.
6. Piping connection location and sizes.
7. Wiring diagram indicating internal wiring and controls and point of external connection.
8. Sound data.

B. Submit maintenance and operating manuals.

1.4 QUALITY ASSURANCE

A. Construction and ratings shall be in accordance with the most recent ARI Standard 590 / 370.

B. Provide full factory run test for chiller prior to shipment. Submit report for review by Engineer and Owner. Factory run test shall be at specified ambient and water conditions, at full load only. Where two or more identical chillers are purchased, one chiller shall be performance tested. If the tested chiller fails the performance test, the correction shall be made to all chillers and all chillers shall then be tested. The test report results shall be signed by an officer of the company and submitted to the engineer for approval prior to chiller shipment.

1.5 WARRANTY

A. Provide a warranty covering all parts and labor, and refrigerant to the job site ("bumper to bumper", no item excluded) for a period of five years from the date of start-up. Warranty shall include parts and labor to the job site.

B. Compressor shall be warranted for parts only year six (6) thru ten (10).

PART 2 - PRODUCTS

2.2 ACCEPTABLE MANUFACTURER

A. Carrier.

B. Daikin Applied.

C. Trane.

2.3 PERFORMANCE

A. The chiller shall meet or exceed the scheduled capacity at the scheduled design conditions.

2.4 COMPRESSORS

A. Compressors are to be scroll or screw type. Refer to equipment schedules for type of chillers to be provided on this project.

B. Where scroll type compressors are utilized, they shall be designed for use with R-410a. Scroll compressors shall be equipped with hot gas bypass on the first circuit to allow unloading and operation to 10% capacity.

1. Isolation valves shall be provided to isolate each circuit and facilitate service. Chiller kW ratings shall be based on low nominal voltage (i.e. 460 volts for 480 volt rating, 200 volts for 208 volt rating).

2. Direct drive motor cooled by suction gas with only three major moving parts and a completely enclosed compression chamber which leads to increased efficiency.

3. Each compressor will have crankcase heaters installed and properly sized to minimize the amount of liquid refrigerant present in the oil sump during off cycles.

C. Where screw type compressors are utilized, they shall be designed for use with R-134. Refrigerant isolation valves shall be provided to isolate each circuit and facilitate service. Chiller kW Ratings shall be based on low nominal voltage (i.e. 460 volts for 480 volt rating, 200 volts for 208 volt rating). Provide compressor heater to evaporate refrigerant returning to compressor during shut down. Energize heater when compressor is not operating.

1. Constant speed screw compressors shall be equipped with slide valve unloading to allow operation to 25 % capacity. Provide constant speed 3600 rpm for 60Hz compressor motor,

suction gas cooled with robust construction and system design protection, designed for across-the-line or wye-delta starting. Furnish with starter and high capacity circuit breaker (minimum short circuit current rating of 65,000 amps).

2. Variable speed screw compressors shall be provided with similar accessories but shall include variable speed drives on each compressor.

    i. The water chiller shall be furnished with a variable speed drive (VSD) to minimize maintenance and maximize cooling efficiency. The VSD shall be factory mounted on the chiller and shipped completely factory assembled, wired and tested.

    ii. The VSD will be specifically designed to interface with the water chiller controls and allow for the operating ranges and specific characteristics of the chiller. The VSD control logic shall optimize chiller efficiency by coordinating compressor motor speed to maintain the chilled water setpoint.

    iii. The VSD efficiency shall be 95% or better at full speed and full load. Fundamental displacement power factor shall be a minimum of 0.95.

    iv. The VSD shall be solid state, microprocessor based pulse-width modulated (PWM) design. The VSD shall be voltage and current regulated. Output power devices shall be IGBT transistors.

    v. Power semi-conductor and capacitor cooling shall be from a liquid cooled heatsink.

    vi. The VSDs shall each be furnished in a UL 1995 rated metal enclosure having as minimum a short circuit withstand rating of 65,000 amps. It will include three phase input lugs plus a grounding lug for electrical connections, output motor connection via factory installed bus bars and all components properly segregated and completely enclosed in a single metal enclosure.

        1. Enclosure shall include a pad-lockable, door-mounted circuit breaker with shunt trip and AIC rating of 65,000 amps.

        2. The entire chiller package shall be UL/CUL listed.

    vii. The following VSD status indicators shall be available to facilitate startup and maintenance:

        1. Output speed in hertz and rpm

        2. Input line voltage

        3. Input line kW

        4. Output/load amps

        5. Average current in percent RLA

6. Load power factor

7. Fault

8. VSD transistor temperature

viii. The VSD shall include the following features:

1. All control circuit voltages are physically and electrically isolated from power circuit voltage.

2. Soft start, adjustable linear acceleration, coast-to-stop.

3. Adjustable current limiting and UL approved electronic motor overload protection.

4. Insensitivity to incoming power phase sequence.

5. VSD and motor protection from the following faults:

a. Output line-to-line short circuit protection
b. Line-to-ground short circuit protection
c. Phase loss at AFD input
d. Phase reversal / Imbalance
e. Over-voltage / Under-voltage
f. Over temperature

D. Provide louvered panels for the compressor / evaporator section. Paint louvers to match the color of the remainder of the unit. Maximum opening shall not exceed ½".

2.5 EVAPORATOR

A. For Scroll Compressor Units, provide a shell and tube or plate and frame evaporator with single (up to 40 ton) or dual (for 40 ton or above) independent refrigerant circuits on multiple compressor units. For Screw Compressor Units, provide a shell and tube evaporator and independent circuits per compressor.

B. Fabricate evaporator shell of seamless or welded steel with removable cast iron or steel heads.

C. Construct evaporator using seamless copper or red brass tubes roller expanded or silver brazed into tube sheets.

D. Provide intermediate tube supports between tube sheets not over 3 feet apart.

E. Design water side for 150 psig working pressure and test at not less than 1.5 times maximum working pressures.

F. Design and test refrigerant side for 225 psig in accordance with the ASME Code. Provide evaporator having ASME stamp.

G. Insulate shell with 3/4 inch thick, closed cell foam plastic, vapor barrier insulation having a maximum K value of 0.26.

H. Provide evaporator with water drain connections and thermometer wells for temperature controller and low temperature cutout. Provide connections for pressure drop testing on chilled water inlet and outlet. These features can be provided on the piping connections to the chiller.

I. Provide heater cable beneath insulation for freeze protection down to 0 degrees F.

J. In the event the chiller manufacturer is using a Plate & Frame heat exchanger in lieu of a Shell and Tube heat exchanger for the design of their evaporator section, the manufacturer shall provide a 40 mesh strainer at the inlet connection to the evaporator.

1. Braze plates shall be stainless steel with copper braze material.

2. The evaporator shall be protected with an etched foil heater and insulated with 3/4 inch insulation. This combination shall provide freeze protection down to -20F ambient temperatures while the heater is powered. Contractor shall provide separate power to energize heater and protect evaporator while chiller is disconnected.

2.6 CONDENSER

A. Construct condenser coils of microchannel all aluminum brazed fin construction. The condenser coils shall have an integral sub-cooling circuit and shall be designed for at least 650 psig working pressure. Leak tested at 715 psig. Coils can be cleaned with high pressure water.

B. Or the condenser coils shall consist of copper tubes mechanically bonded into plate-type aluminum fins. A sub-cooling coil shall be an integral part of the main condenser coil.

C. When site is within 50 miles of the coast, provide a complete, flexible epoxy dip and back coating of tube and fin condenser coils. Coil with coating shall be able to handle 5,000-hour sales spray test. All coil surfaces shall be coated with epoxy material giving uniform coverage (minimum of 0.6 mils), without bridging between fins. Any coating showing bridging will be unacceptable. Coatings not covering any part of the fin and/or parts of condenser frame will be unacceptable. Backed phenolic coatings are unacceptable because of their brittle nature. The heat transfer decrease due to the coating shall be less than 1% so that design capacity and efficiency are maintained. Baked Phenolic coatings are also unacceptable due to performance losses of up to 5%. If backed phenolic is allowed, unit provided must account for performance degradation. Coating shall be able to withstand corrosive environments in the pH range of 3 - 12. Coating shall be flexible so that bare surfaces will not form. The coating shall be able to handle temperatures ranging from -40 F to 150 F without degradation. UV protection shall be applied on surface of coating to prevent degradation from sunlight.

D. Unit shall be capable of starting and running at outdoor ambient temperatures from 32F to 125F

***** OR *****

E. Unit shall be capable of starting and operating at outdoor ambient temperatures from 0F to 125F.

F. Provide factory mounted, louvered, "architecturally pleasing" panels. Panel louvers shall cover the condenser coils and protect from hail.

G. CONDENSER FANS AND MOTORS

1. Low Sound Fans shall be dynamically and statically balanced, direct drive, corrosion resistant glass fiber reinforced composite blades molded into a low noise fan blade.

2. Statically and dynamically balance fans.

3. Provide blade guards on fan discharge.

4. Low speed fan motors shall be three-phase with permanently lubricated ball bearings and individually protected by circuit breakers.

5. Provide an electric motor for each condenser fan. Motors shall have permanently lubricated ball bearings and overload protection. Motor shall be of TEFC design; ODP motors are prohibited.

F. CONTROLS

a. A microprocessor-based control system shall be utilized for precise monitoring and control of the air cooled chiller based on the leaving evaporator water temperature. The microprocessor-based control system shall be equipped with a DDC interface card to allow for remote monitoring of the chiller status, including operating conditions as well as alarms through discrete I/O interface (analog and digital inputs or outputs). Open protocol DDC interface card if supplied in addition to discrete I/O interface shall be compatible with Andover building energy management control system (EMCS).

b. The microprocessor controller shall provide multiple steps of fan control for each circuit to maintain optimum condenser pressure control for maximum operating unit efficiencies.

c. The microprocessor shall continuously calculate the optimum condenser pressure for each circuit based upon compressor capacity, outside air temperature and number of condenser fans in operation.

d. The chiller shall be provided with a 0-10V DC module to interface with the Building Automation and Control System.

e. The controller shall feature an easy-to-use, 12-key keypad and 32-character digital display that provides access to temperatures, pressures, setpoints, operating states, schedules and alarm messages in plain English. Coded messages are not acceptable.

f. The controller shall include password protection to guard against unauthorized or accidental setpoint or parameter changes.

g. Provide on the chiller a fully enclosed, weatherproof factory wired, steel control panel(s) complete with lock.

h. Provide the following operating controls:

i. Control power transformer of sufficient capacity to carry all 120-volt chiller loads including, but not limited to the chiller control panel and the evaporator heater.
ii. Control power fuse or circuit breaker.
iii. Control power on-off device.

i. Automatic capacity controller.

j. Switches for manual and automatic operation of the oil pump.

k. Indicating display for each crankcase heater.

l. Ability to change compressor starting sequence.

m. Timer to prevent compressor rapid cycling.

n. Indicating display for each compressor.

o. Indicating display signal for compressor discharge pressure, evaporator pressure, condenser pressure and oil pressure.

p. Demand limiting switch.

i. Timed periodic pump down device.
ii. Compressors disable feature for service.
iii. Low ambient operation down to 0°F.

q. Provide the following controls arranged so that any one control will shut down the machine and require manual reset.

r. Proof of flow switch shall be factory installed the correct number of pipe diameters from any elbow and in the correct orientation. In addition, the flow switch shall be factory wired. Flow switch shall be IFM flow monitor type.

s. Low water temperature sensor.

t. Refrigerant high pressure sensor.

u. Refrigerant low pressure sensor.

v. Compressor motor winding high temperature sensor.

w. Low oil pressure sensor.

x. Phase failure.

i. Freeze protection for each circuit.
ii. Over/under voltage protection.

G. ACOUSTIC DESIGN FEATURES

a. Chiller shall be designed to provide a reduced noise profile.

b. Chillers shall be provided with all necessary items to meet the scheduled sound criteria.

H. ENCLOSURES

a. Mount starters in a UL1995 rated panel for outdoor use.

b. The starter shall be across-the-line configuration, factory-mounted and fully pre-wired to the compressor motor(s) and control panel.

c. Unit shall have a single point power connection.

d. A control power transformer shall be factory-installed and factory-wired to provide unit control power.

e. Control panel shall be dead front construction for enhanced service technician safety.

f. A molded case standard interrupting capacity circuit breaker shall be factory pre-wired with terminal block power connections and equipped with a lockable external operator handle, making it available to disconnect the chiller from main power. The unit shall have a high fault rated control panel with 65,000 amp short circuit current rating

g. Unit wiring shall run in liquid-tight conduit.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Align chiller concrete foundation, sole plates, and sub-bases. Level, grout, and bolt in place.

B. Arrange piping for easy dismantling to permit tube cleaning.

C. In the event the chiller manufacturer is using a Plate & Frame heat exchanger in lieu of a Shell and Tube heat exchanger for the design of their evaporator section, the manufacturer shall provide a 40 mesh strainer at the inlet connection to the evaporator.

3.2 START-UP

A. Supply initial charge of refrigerant and oil.

B. Supply service of factory trained representative for a period of 2 days to supervise testing, dehydration, charging of machine, start-up, and instruction on operation and maintenance to Owner.

END OF SECTION 23 64 23

SECTION 23 64 27 - REFRIGERANT MONITORING AND SAFETY EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes refrigerant monitors, alarms, and breathing apparatus.

1.3 DEFINITIONS

A. CMOS: Ceramic metal-oxide semiconductor.

B. HFC: Hydrofluorocarbon.

C. HCFC: Hydrochlorofluorocarbon.

D. IR: Infrared.

E. LED: Light-emitting diode.

F. ppm: Parts per million.

G. SCBA: Self-contained breathing apparatus.

1.4 SUBMITTALS

A. Product Data: For SCBA; include mounting details and service requirements and compliance with authorized Federal agency.

B. Shop Drawings: For each type of refrigerant monitor; include refrigerant ppm range, temperature range, alarm outputs, readout range, furnished specialities, installation requirements, and power consumption.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Include machinery room layout showing location of monitoring devices in relation to refrigerant equipment.

D. Product Certificates: For monitoring devices and SCBA, signed by product manufacturer.

E. Operation and Maintenance Data: For refrigerant monitoring equipment and SCBA to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. ASHRAE: Monitoring system shall comply with ASHRAE 15.

B. CFR: SCBA shall comply with requirements in 42 CFR 84.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. 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:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Refrigerant Monitoring Equipment:
   a. Davis Instruments Manufacturing Co., Inc.
   b. Foxboro Company (The).
   c. General Analysis Corp.
   d. Genesis International Inc.
   e. Thermal Gas Systems, Inc.; Haloguard Monitors.

2. SCBA:
   a. AFC International, Inc.
   b. Clarey's Safety Equipment, Inc.
   c. Genesis International Inc.
   d. MSA, Instrument Division.
   e. Thermal Gas Systems, Inc.; Haloguard Monitors.

2.2 FUNCTIONAL DESCRIPTION OF REFRIGERANT MONITORING SYSTEM

A. On leak detection by refrigerant sensor(s), the system shall perform the following:

1. Activate emergency machinery room ventilation.
2. Activate audio and visual alarm inside and outside machinery room.
3. Shut down combustion process where combustion equipment is employed.
4. Notify Building Automation System of alarm condition.
5. Operate shunt-trip breakers.

2.3 REFRIGERANT MONITOR

A. Description: CMOS or IR sensor shall continuously measure and display the specific gas concentration and shall be capable of indicating, alarming, and shutting down equipment, and automatically activating ventilation system.

B. Performance Requirements:

1. Refrigerant to Be Monitored: HFC-134a.
2. Refrigerant Concentration: 0 to 1000 ppm.
3. Accuracy: 100 to 1000 ppm; plus or minus 10 percent of reading.

4. Linearity: 100 to 1000 ppm; plus or minus 2 percent of full scale.
5. Sensitivity: 1 ppm.
6. Resolution: 1 ppm.
7. Operating Temperature: 41 to 104 deg F (5 to 40 deg C).
8. Response Time: 90 percent of a step change in 4 minutes.
9. Relatively Humidity: 20 to 95 percent, noncondensing over the operating temperature range.

C. Operating Requirements:

1. Maximum Power Input: 120-V ac; 60 Hz, 30 W.
2. Alarm Relays: 3 relays at 5- to 8-A resistive load.
3. Alarm Set Points: Displayed on front of meter.
4. Audible Output: Sonic alert at 75 to 80 dB at 60 inches (1525 mm).
5. Analog Output: 0- to 10-V dc or 4- to 20-mA current sourcing.
6. Serial Output Type: RS 232.

D. Sensor Configuration: Photoacoustic IR sensor.

1. Single-sensing channel.
2. Expandable to four (4) channels.

E. Display: 10-character, alphanumeric, vacuum-fluorescent indicating lights for each alarm set point; standard alarm; acknowledge switch and test switch mounted on front panel; and alarm status LEDs and service fault LEDs.

1. Enclosure: NEMA 250, type as required for ambient condition.

F. Alarm Output: Indicating light flashes and horn sounds.

1. Unit-mounting device with single-light beacon.
2. Remote unit for mounting outside machinery room and having light beacon with double lights.
3. Field-adjustable alarm set points.

G. Calibration: Factory calibrated.

2.4 SCBA

A. Description: Open-circuit, pressure-demand, compressed-air SCBA includes completely assembled, portable, self-contained devices designed for hazardous breathing environment application.

B. Face Piece: EPDM construction material, one-size-fits-all with double-sealing edge, stainless-steel speaking diaphragm and lens retainer, five adjustable straps to hold face piece to head (two straps on each side and one on top), exhalation valve in mask, close-fitting nose piece to ensure no CO_2 build-up, and perspiration drain to avoid skin irritation and to prevent eyepiece, spectacle, and lens fogging.

C. Backplate: Orthopedically designed of high-strength chemical and impact-resistant glass-fiber composite.

D. Harness and Carrier Assembly: Large triangular back pad, backplate, and adjustable waist and shoulders straps. Modular in design, detachable components, and easy to clean and maintain. Shoulder straps are padded with flame-resistant material and reinforced with stainless-steel cable and attached with T-nuts, washers, and screws; rivets are not permitted.

E. Air Cylinder: Forty-five-minute, low-pressure, air-supply-loaded fiberglass cylinders fitted with quick-fill assembly for refilling and air transfer.

F. Wall-Mounted Case: Leakproof, corrosion-resistant, tough, lockable, plastic case.

2.5 CONTROL CABLE

A. Electronic and fiber-optic cable for control wiring shall be as specified in Division 26 Section "Control/Signal Transmission Media."

2.6 SOURCE QUALITY CONTROL

A. SCBA: Tested and certified by the National Institute for Occupational Safety and Health and the Mine Safety and Health Administration according to 42 CFR 84, Subpart H.

B. Refrigerant Monitor: Factory tested and certified.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine chiller layout for proper location of monitoring device.

B. Verify refrigerant contained in chiller(s) to ensure compatibility of refrigerant monitor.

C. Examine machinery room ventilation system to verify its operation with refrigerant monitor(s).

3.2 INSTALLATION

A. Install refrigerant monitoring equipment level and plumb.

B. Install labels and nameplates to identify monitoring devices and SCBA components according to Division 23 Section 23 05 53 "Mechanical Identification."

C. Install building wire and cable according to Division 26 "Conductors and Cables."

D. Install signal and communication cable according to Division 26 Section "Control/Signal Transmission Media."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:

1. Inspect field-assembled components, equipment installation, and electrical connections for compliance with requirements.
2. Test and adjust controls and safeties.
3. Test Reports: Prepare a written report to record the following:
   a. Test procedures used.
   b. Test results that comply with requirements.
   c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.4 ADJUSTING

A. Adjust alarm set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain refrigerant monitoring devices.

B. Training: Provide a "how-to-use" SCBA video that details exact operating procedures of equipment.

END OF SECTION 23 64 27

SECTION 23 65 00 - COOLING TOWER

PART 1 - GENERAL

1.1 WORK INCLUDED

Factory fabricated, field assembled induced draft crossflow with vertical air discharge cooling tower and related accessories.

1.2 QUALITY ASSURANCE

A. Provide a five year warranty against defects in parts, including fan motor, drive system; bearings and structure from date of final acceptance of the project.

B. Design Criteria:

1. Cooling Tower shall be FM Approved for multi-cell installation.
2. Design to withstand 30 psf windload.
3. Free water drift loss shall be not greater than one tenth of one percent of water circulated to tower.
4. The cooling tower cell dimensions as indicated on the schedule.

C. Performance Criteria:

1. Manufacturer shall certify that performance of cooling tower will meet contract requirements, stating entering air wet bulb temperature, entering and leaving water temperatures, water flow rate, airflow volume and fan horsepower. Certification shall be made at time of submittal.
2. Acoustic Performance. Provide documentation for:

    a. Overall dBA level at 75 ft.
    b. Spectral Distribution for Air Inlet, End and Top at 75 ft. SPL ref. 20 micro Pascals, bands 1 thru 8.
    c. Sound Power Level Spectrum PWL ref. 1 picowatt, bands 1 thru 8.

3. In the event the cooling tower fails to perform as specified, Contractor shall make corrections or replace the cooling tower. This procedure shall be repeated, at no additional cost to the Owner, until the cooling tower test confirms that the cooling tower performs as specified.

4. CTI Certification notwithstanding, the cooling tower manufacturer shall guarantee that the tower supplied will meet the specified performance conditions when the tower is installed according to plan. If, because of a suspected thermal performance deficiency, the owner chooses to conduct an on-site thermal performance test under the supervision of a qualified, disinterested third party in accordance with CTI or ASME standards during the first year of operation; and if the tower fails to perform within the limits of test tolerance; then the cooling tower manufacturer will pay for the cost of the test and will make such corrections as are appropriate and agreeable to the owner to compensate for the performance deficiency.

D. Warranty:

1. The entire tower, including structure, casing, basins, decking, fan(s), motor(s), and all mechanical drive components (including belts, if used) shall be warranted against failure due to defects in materials and workmanship for a period of five (5) years from the date of shipment to the job.

E. Design Loading:

1. The tower structure, anchorage and all its components shall be designed by licensed professional engineers, employed by the manufacturer, per the International Building Code to withstand a wind load of 30 psf, as well as a .3g seismic load. The fan deck, hot-water basin covers and, where specified, maintenance platforms shall be designed for 60 psf live load or a 200 lb concentrated load. Guardrails, where specified, shall be capable of withstanding a 200 lb concentrated live load in any direction, and shall be designed in accordance with OSHA guidelines.
2. The tower shall be structurally capable of being supported at the four outer corners of the tower cell. Alternatively, the tower manufacturer shall provide supporting steel to adapt tower to be supported at four outer corners.

1.3 SUBMITTALS

A. General Requirements for All Mechanical and Plumbing Work.

B. Capacity data, power requirements, fan characteristic curve.

C. Submit curves showing predicted performances as required by ASME Test Code PTC-23 paragraph 7.02.

D. Qualifications of testing agency.

E. Manufacturer:

1. Marley.
2. BAC.

PART 2 - PRODUCTS

2.1 CONSTRUCTION

A. Except where otherwise specified, all components of the cooling tower shall be fabricated of series 301L stainless steel. The tower shall be capable of withstanding water having a chloride content (NaCl) up to 750 ppm; a sulfate content (SO4) up to 1200 ppm; a calcium content (CaCO3) up to 800 ppm; and silica (SiO2) up to 150 ppm. The circulating water shall contain no oil, grease, fatty acids, or organic solvents.

Fiberglass casing, polyurethane barriers, and thermosetting hybrids and the components they are adhered to shall be considered non-recyclable and not allowed.

B. The specifications, as written, are intended to indicate those materials that will be capable of withstanding the above water quality in continuing service, as well as the loads described in paragraph 4.1. They are to be regarded as minimum requirements. Where component materials peculiar to individual tower designs are not specified, the manufacturers shall take the above water quality and load carrying capabilities into account in the selection of their materials of manufacture.

C. The tower shall be listed in the current FM Approval Guide (approvalguide.com) and conform to the FM Approval Standard for Cooling Towers, Class Number 4930 that is approved for use without sprinkler systems. The tower shall have successfully passed full scale fire testing, static and cyclic wind pressure testing, large missile impact testing (for Zone HM), and structural design evaluation as administered by FM Approvals. A copy of the FM Approval Certificate of Compliance, dated November 2013 or later shall be available upon request.

2.2 MECHANICAL EQUIPMENT:

A. Fan(s) shall be propeller-type, incorporating aluminum alloy blades attached to galvanized hubs with U-bolts. Blades shall be individually adjustable. Maximum fan tip speed shall be 13,000 ft/min. Fan(s) shall be driven through a right angle, industrial duty, oil lubricated, geared speed reducer that requires no oil changes for the first five (5) years of operation. All gearbox bearings shall be rated at an L10A service life of 100,000 hours or greater and the gear sets shall have AGMA Quality Class of 9 or greater. The gearbox shall include any modifications to enable operation down to 10% of full speed.

An external oil level dipstick shall be located adjacent to the motor at the fan deck surface and shall be accessible from a portable maintenance ladder.

B. Single-speed motor(s) shall be 3 Hp maximum, NEMA Premium Efficiency, TEFC, 1.15 service factor, inverter duty, variable torque, and specially insulated for cooling tower duty (Class F). Speed and electrical characteristics shall be 900 rpm, single-winding, 3-phase, 60 Hz, 208 volts. Motor shall operate in the shaft-horizontal position for geardrive towers and shaft-down position for belt drive towers. Nameplate horsepower shall not be exceeded at design operation.

C. The motor to gearbox close coupling shall be a tire-type, single piece, flexible element design to accommodate frequent speed changes that are inherent with VFD applications.

D. The complete mechanical equipment assembly for each cell shall be supported by two horizontal steel beams that resist misalignment between the motor and the gear reducer/ belt drive system.

A vibration limit switch in a NEMA 4 housing shall be installed on the mechanical equipment support and wired to the shutdown circuit of the fan motor starter or VFD. The purpose of this switch will be to interrupt control power voltage to a safety circuit in the event of excessive vibration causing the starter or VFD equipment to de-energize the motor. It shall be adjustable for sensitivity, and include a means to reset the switch. Switch shall by double-pole, double-throw (DPDT).

2.3 FILL, LOUVERS & DRIFT ELIMINATORS:

A. Fill shall be film type, thermoformed of PVC, with louvers and eliminators formed as part of each fill sheet. Fill shall be suspended from stainless steel structural tubing supported from the tower

structure, and shall be elevated above the floor of the cold-water basin to facilitate cleaning. Air inlet faces of the tower shall be free of water splash out.

B. Drift eliminators shall be PVC, triple-pass, and shall limit drift losses to 0.005% or less of the design water flow rate.

2.4 HOT WATER DISTRIBUTION SYSTEM:

A. Two open stainless steel basins (one above each bank of fill) shall receive hot water piped to each cell of the tower. These basin components shall be installed and sealed at the factory and assembled with bolted connections. Tap screws shall not be allowed. The basins shall be equipped with removable, stainless steel covers capable of withstanding the loads described in paragraph 4.1. The water distribution system shall be accessible and maintainable during tower fan and water operation.

B. Each cell of the tower shall include a single hot-water inlet connection located as shown on the plans. An internal system of PVC piping shall deliver water equally to the distribution basins without the need for balancing valves. This internal piping system shall require no scheduled maintenance, and shall be located such that it does not interfere with normal maintenance access. The internal piping shall extend to the exterior surface of the tower.

The water distribution system shall be equipped with a method to operate under variable flow conditions while maintaining a uniform air-side pressure drop through the fill to maximize cooling efficiency and minimize the risk of ice and scale formation in the fill. System must accommodate flow rates down to 50% of design flow.

C. The water distribution system shall be accessible and maintainable while tower is operating. Isolation valves shall be provided in the common PVC piping serving the hot water basins.

2.5 CASING, FAN DECK AND FAN CYLINDER:

A. The casing and fan deck shall be stainless steel, and shall be capable of withstanding the loads described in paragraph 4.1. The top of the fan shall be equipped with a conical, non-sagging, removable fan guard, fabricated of welded 5/16" and 7 gauge rods, and hot dip galvanized after fabrication. Fan cylinders 5'-0" in height and over shall not be required to have a fan guard.

The air inlet faces of the tower shall be covered by 1" mesh hot-dipped galvanized welded wire screens. Screens shall be secured to removable galvanized U-edge frames. Screens shall be designed to permit full access to the cold-water basin by removal of one panel on each air inlet.

2.6 ACCESS:

A. A large stainless steel, rectangular access door shall be located on both cased faces for entry into the cold-water basin. Doors shall provide convenient access to the fan plenum area to facilitate inspection and allow maintenance to the fan drive system. The access doors shall be at least 30" wide by 33" high.

The top of the tower shall be equipped with a guardrail complete with kneerail and toeboard, designed according to OSHA guidelines and factory welded into subassemblies for ease of field installation. Posts, toprails and kneerails shall be 1.5" square tubing. The guardrail assembly shall be hot dipped galvanized after welding and capable of withstanding a 200 pound concentrated live load in any direction. Posts shall be spaced on centers of 8'-0" or less. A 1'-6" wide aluminum

ladder with 3" I-beam side rails and 1.25" diameter rungs shall be permanently attached to the endwall casing of the tower, rising from the base of the tower to the top of the guardrail.

Provide a ladder extension for connection to the foot of the ladder attached to the tower casing. This extension shall be long enough to rise from the roof (grade) level to the base of the tower. The installing contractor shall be responsible for cutting the ladder to length; attaching it to the foot of the tower ladder; and anchoring it at its base.

A steel, self-closing gate shall be provided at the guardrail level of the ladder.

2.7 COLD WATER COLLECTION BASIN:

A. The collection basin shall be welded 301L stainless steel construction. Only low-carbon stainless steel alloys will be accepted in order to minimize the risk of intergranular corrosion in the weld zones. The basin shall include the number and type of suction connections required to accommodate the outflow piping system shown on the plans. Suction connections shall be equipped with stainless steel debris screens. An overflow and drain connection shall be provided in each cell of the cooling tower. The basin floor shall slope toward the drain to allow complete flush out of debris and silt that may accumulate. Towers of more than one cell shall include a method for isolation of cells and flow equalization between cells. The basin shall be accessible and maintainable while water is circulating. All steel items that project into the basin shall also be made of stainless steel.

Provide a water level control system including a NEMA 4X control panel, water level probes and probe stilling chamber. The control system shall monitor the water level in the cold-water basin to determine level events used for cold-water make-up, high and low alarms or pump shut down. The control panel shall use electromechanical relays providing power for the make-up solenoid and electrical contacts for alarm and pump shutdown control circuits. Probes shall be contained in a vertical stilling chamber to stabilize the water in the cold-water basin. Probes shall have replaceable stainless steel tips and level height shall be field adjustable.

B. Provide a system of electric immersion heaters and controls for each cell of the tower to prevent freezing of water in the collection basin during periods of shutdown. The system shall consist of one or more stainless steel electric immersion heaters installed in threaded couplings provided in the side of the basin. A NEMA 4 control panel and associated temperature probe shall include circuitry to monitor cold water temperature and low water level, providing ON OFF thermostatic like control. The temperature probe shall be located in the cold-water basin. The system shall be capable of maintaining 40°F water temperature at an ambient air temperature of 10 °F.

The interconnecting flume between cells shall be equipped with a removable cover plate to permit the shutdown of one cell for maintenance purposes, or to permit independent cell operation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify that the equipment and materials comply with approved shop drawings, manufacturer’s submittals and contract documents.

B. Bolted construction or self-tapping screws shall be used throughout to attach casing to tower frame.

C. Provide support beams, platform hangers and anchor bolts required for the proper installation of equipment.

END OF SECTION 23 65 00

SECTION 23 73 13 - AIR HANDLING UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Factory Built Central Station Air Handling Unit.

1.2 SUBMITTALS

A. Submit manufacturer's product data including the following:

1. Dimensional data and weights.
2. Materials and methods of construction.
3. Fan performance curves with operating point plotted.
4. Coil computer selection calculations.
5. Total air leakage in accordance with ASHRAE 111 (or manufacturer shall be responsible for cost of a field leakage test by Test and Balance Contractor if compliance documentation not available for unit submitted)
6. Motor data.
7. Discharge and radiated sound power levels.

1.3 QUALITY ASSURANCE

A. All units shall be tested, rated and certified as complete units in accordance with AHRI Standard 430, and shall bear the AHRI seal. Where multiple fans are used, units shall be tested in accordance with AHRI 410 for airflow, static pressure and fan speed performance but the label shall not be required.

B. Coil performance shall be tested, rated and certified in accordance with AHRI Standard 410, and shall bear the AHRI seal.

C. Coils shall be tested under water with compressed air to 325 PSIG.

D. Fan performance ratings: Fans shall be tested as an assembly in the air handling unit. Fan curves shall be provided per AHRI 430.

E. Sound ratings: AHRI 260.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Carrier.

B. Daikin Applied.

C. Trane.

2.2 APPARATUS CASING

A. The unit shall be an assembly of sections having the same casing construction except as noted below.

Casing shall completely enclose all components (i.e. coil ends, fan motors, etc.). The entire unit shall be a minimum two inch, double walled construction. Casing panels shall be fabricated of G-90 galvanized steel with reinforcement as necessary to prevent pulsation and bulging. The unit shall be designed and constructed to withstand the pressures required by the system, but not less than 8.00" static pressure.

B. The unit structural frame shall be constructed of structural steel components. The unit shall have an independent, self-supporting, frame construction that, when fitted with casing panels, provides an overall unit rigidity with deflection not less than L/240. The frame shall be built to permit complete removal of the wall and roof panels without affecting the structural integrity of the unit.

C. Casing performance – Casing air leakage shall not exceed Class 6 (CL=6) per ASHRAE 111 at specified casing pressure, where maximum casing leakage (cfm / 100 ft2 of casing surface area) = CL X P0.65. Air leakage shall be determined at 1 times maximum casing static pressure up to 8 inches w.g. Specified air leakage shall be accomplished without caulk. Total estimated air leakage shall be submitted for each unit in CFM, as a percentage of supply air, and as an ASHRAE 111 Leakage Class.

D. Under 55F supply air temperature and design conditions on the exterior of the unit of 81F db and 73F wb, condensation shall not form on the casing exterior. The AHU manufacturer shall provide tested casing thermal performance for the scheduled supply air temperature plotted on a psychometric chart. If tested casing thermal data is not available, AHU manufacturer shall provide, in writing to the engineer and owner, a guarantee against condensation forming on the unit exterior at the stated design conditions above. The guarantee shall note that the AHU manufacturer will cover all expenses associated with modifying units in the field should condensate form on them.

E. Floor panels shall be double-walled construction and designed to support a 300-lb load during maintenance activities and shall deflect no more than 0.0042 per inch of panel span.

F. Casing panels shall be constructed of 2" double walled, foam injected G-90 galvanized steel with an R-value not less than R-13. External panel shall be of 18-gauge construction, with internal gauge as necessary by panel size to achieve specified deflection All insulation products shall meet ASTM E-84, NFPA 90A and U.L. requirements.

G. Where units are designed to provide airflow in excess of 15,000 CFM, accessible sections of the unit shall be provided with tread plate floor. Accessible sections provided with tread plate construction shall be equipped with service doors not less than 18" wide.

H. The entire unit shall have a full length, 6" structural base rails with cross members adequate to support all unit components. Condensate drain connection shall not penetrate the structural base.

I. Drain pans shall be full width and extend completely under the coil section. They shall be sloped in two directions to the drain side of the unit. Unit shall drain all water from the drain pan within five minutes after the unit has shutdown. The unit shall have a minimum 1-1/4 inch threaded drain connections. Drain pans shall be sealed double wall steel construction with rigid glass fiber insulation and Type 316 stainless steel inner pan. Drain pans shall have at least 2" of uncompressed insulation or 1/2" of foamed-in-place insulation and shall be a minimum of 4" deep. Coils with finned height greater than 48" shall have a stainless steel intermediate drain pan extending the entire finned length of the coil. The intermediate drain pan shall have drop tubes to guide condensate to the main drain pan.

J. Access doors shall be hinged, double wall insulated type with gasket seals completely around the opening and camlock latches. Provide doors on the drive side of fan sections, in coil sections and in side access filter sections. Provide additional access sections where required to perform

manufacturer's recommended maintenance procedures. Except at filter sections, minimum access section width shall be based on installation of a 12" wide access door. Access doors shall be provided as close as possible in size to the height and width of the section in which they are installed.

2.3 FAN SECTION

A. Fan assembly shall have a galvanized steel channel base with structural steel supports for the fan, motor and drive assembly.

B. Internally isolate the fan motor and drive factory mounted on a structural steel base with 2-inch deflection springs, discharge flexible connector, and thrust restraint springs.

C. The fan segment shall be equipped with single or double width, single or double inlet centrifugal type wheels. All fans shall have Forward Curve (FC), Airfoil (AF), Direct Drive Plenum (DDP) or Motorized Impeller with ECM motor (MI) type as indicated on the schedule.

D. After the pre-balanced fan is installed in the air handler, the entire fan section shall be run-balanced at the specified speed to insure smooth and trouble-free operation. The fans then will be checked in the factory from 25% to 100% of design RPM to insure they are operating within vibration tolerance specifications, and that there are no resonant frequency issues throughout this operating range. Inverter balancing that requires lockout frequencies inputted into a variable frequency drive to in order to bypass resonant frequencies shall not be acceptable.

E. Fan shafts shall be solid steel ground and polished. Wheels shall be keyed to the shaft and designed for continuous operation at the maximum rated speed and horsepower. Fan wheels and shafts shall be selected at a minimum of 25% below the first critical speed.

F. The rotating assembly shall be statically and dynamically balanced at the factory. Refer to Section 23 05 00 for minimum acceptable vibration criteria. Equipment not meeting these criteria will be repaired or replaced at no cost to the Owner. If fans and motors are not internally isolated, then the entire unit shall be externally isolated from the building, including supply and return duct work, piping, and electrical connections.

G. Bearings shall be self-aligning, greasable, pillow block ball or roller bearings with lubrication fittings extended to the drive side and located within the casing. Bearings shall have an average life of 200,000 hours at design conditions in accordance with ANSI B3.15.

H. Motors shall be premium efficiency totally enclosed air over type or premium efficiency ODP in accordance with Section 23 05 13. Motor speed shall not exceed 1800 RPM for FC or AF fans. Factory-mount motors on adjustable slide rails.

I. Belt Drive units shall be fixed pitch type. Drives shall be designed for 150% of the motor nameplate horsepower. Belts shall be factory furnished.

J. For units with multiple fan array, each direct drive fan shall be provided with integral ECM motors. These motors are to be controlled by 0-10VDc signal.

K. When units with multiple-fan array is specified, each direct drive fan shall be provided with integral back flow prevention damper that prohibits recirculation of air in the event a fan or multiple fans become disabled. Dampers are tested and rated based on AMCA Standard 500. Dampers to be heavy duty type capable of a maximum back pressure that exceeds the design total static pressure with minimal leakage. The dampers should have a minimal total effect on airflow performance. The damper

blades and frame shall be extruded aluminum with blade edge seals locked into the blade edge. Adhesive type seals are unacceptable. AHU manufacturer responsible for providing proper spacing upstream of dampers to ensure full, uniform airflow through upstream components. For units where the damper(s) are supplied at the jobsite, the installing contractor shall contract a certified TAB contractor to verify uniform airflow thru upstream components.

**** OR ****

L. Each mechanical room shall be provided with factory blank off plate(s) to seal the inlet for a fan array where a single fan has failed to prevent recirculation back thru the down fan.

M. Direct driven fans shall use 2-pole (3600 rpm), 4-pole (1800 rpm) or 6-pole (1200 rpm) motors, NEMA Design B, with Class B insulation capable to operate continuously at 104 deg. F (40 deg. C) without tripping overloads.

2.4 COILS

A. REFER TO SECTION 23 82 160.

B. When installed, unit coils shall extend a minimum of 4” from outside face of unit. Connections shall be threaded.

2.5 FILTER SECTION

A. The manufacturer shall provide filter section to accommodate 24”x24”x4” filters only. Filters shall have MERV 11 rating.

B. REFER TO SECTION 23 73 13.

2.6 DAMPER SECTIONS

A. Mixing box sections shall have interconnected parallel blade outside air and return air dampers.

B. Dampers shall be constructed of maximum 8-inch wide 16 gauge galvanized steel blades with steel shafts supported by nylon bushings mounted in galvanized steel rigid frame. Sectionalize damper assembly to limit blade length to 50 inches maximum. Dampers shall be ultra-low leakage type Ruskin CD60 or equivalent) with blade and edge seals. Leakage shall not exceed 3 CFM/SQ.FT at 1.0 in. w.g. differential pressure complying with ASHRAE 90.1 maximum damper leakage and shall be AMCA licensed for Class 1A. All leakage testing and pressure ratings shall be based on AMCA Standard 500-D. AHU manufacturer shall submit brand and model of damper(s) being furnished, if not Ruskin CD60.

2.7 MARINE LIGHTS

A. Marine lights shall be provided throughout AHUs as indicated on the schedule and plans but at a minimum shall be included in the fan section. Lights shall be instant-on, light-emitting diode (LED) type to minimize amperage draw and shall produce lumens equivalent to a minimum 75W incandescent bulb (1200 lumens). LED lighting shall provide instant-on, white light and have a minimum 50,000 hr. life.

B. Light fixture shall be weather-resistant, enclosed and gasketed to prevent water and dust intrusion.

C. Fixtures shall be designed for flexible positioning during maintenance and service activities for best possible location providing full light on work surface of interest and not being blocked by technician.

D. All lights on a unit shall be wired in the factory to a single on-off switch.

E. Electrical contractor shall be responsible for providing 115V supply to the factory-mounted marine light circuit.

2.8 CONVENIENCE OUTLET

A. A 15-amp, 115V GFCI convenience outlet shall be provided by the AHU manufacturer. The outlet shall be separate from the load side of the equipment per NEC requirements. Installing contractor shall be responsible for providing 115V supply to the factory-mounted GFCI outlet circuit per NEC (even when single-point power is specified to be provided by AHU manufacturer).

2.9 MOTOR OVERLOAD PANEL FOR FAN ARRAYS

A. A motor overload panel provides a single unit mounted UL508A listed control panel with all fans in an array pre-wired to it, such that one properly sized VFD may be field connected with no additional provisions required for protection of the individual motors. The control panel enclosure will be mounted on the exterior of the fan section and will be NEMA type 1 for indoor units and NEMA type 4 for outdoor units. A single power distribution block shall be provided for connection of the field mounted VFD with one conductor per phase. An electronic motor overload protector with lockable manual isolation switch shall be provided for each motor in the array. Each motor in the array shall be independently grounded with a dedicated green conductor. A minimum of one open ground lug per fan plus one shall be provided for field use. Each motor overload protector shall be provided with an auxiliary contact and all auxiliary contacts will be wired in series to a terminal block for generic trip signaling. The panel will be rated for WYE power systems up to 600V.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Replace sheaves as required for final balancing.

B. Provide filters to protect units during construction. Replace filters at time of final acceptance.

C. Indoor Units:
   1. Mount units on concrete housekeeping pads as specified in Section 23 05 29.
   2. Install ducts and piping to facilitate coil and filter removal and allow access to all sections.

END OF SECTION 23 73 13

SECTION 23 81 23 - COMPUTER ROOM AIR CONDITIONING SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Packaged Direct Expansion Computer Room Air Conditioning Unit (Indoor Section).

B. Air Cooled Condenser (Outdoor Section).

1.2 SUBMITTALS

A. Submit manufacturer's product data including dimensions, materials, fabrication methods, performance data and installation procedures.

1.3 WARRANTY

A. Provide 5 year part and labor (bumper-to-bumper, no item is excluded) warranty for each unit.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Liebert Corporation

B. APC

C. Data-Aire Systems

2.2 PACKAGED INDOOR UNIT

A. Cabinet and frame shall be constructed of heliarc welded tubular steel. Exterior panels shall be insulated with minimum 1", 1-1/2 lbs. density fiber insulation. All panels shall have captive 1/4 turn fasteners and shall be removable for service access. Unit color shall be Z-0420, IBM charcoal.

B. Filter chamber shall be an integral part of system, located within the cabinet serviceable from either end of the unit. The filters shall be rated not less than 20% efficiency (based on ASHRAE 52-76). The filters shall be no less than 4” thick.

C. Fan section shall be down -flow and include two fans designed. The fans shall be centrifugal type, double width, double inlet and shall be statically and dynamically balanced as a completed assembly to a maximum vibration level of two mils in any plane. The shaft shall be heavy duty steel with self aligning ball bearings with a minimum life span of 100,000 hours. The fan motor shall be 1750 RPM and mounted on an adjustable slide base. The drive package shall be two-belt, variable speed, sized for 200% of the fan motor horsepower. The fans shall be located to draw air over the A-frame coil to ensure even air distribution and maximum coil performance.

D. Humidifier shall be of infrared type consisting of high intensity quartz lamps mounted above the water supply. The evaporator pan shall be stainless steel and arranged to be serviceable without

disconnecting high voltage electrical connections. The complete humidifier shall be pre-piped ready for final connection. The infrared humidifier shall have a capacity of 22.1 lb/hr. The humidifier shall be equipped with an automatic water supply system controlled by the microprocessor. The system has an adjustable water over-feed to prevent mineral precipitation. The humidifier shall accurately control space humidity at the designated setpoint with maximum of plus or minus 2-1/2% variance.

E. Electric reheat coils shall be low watt density, 304/304 stainless steel fin tubular construction, protected by thermal safety switches and shall be controlled in three equal stages.

F. The compressors shall be located in a separate compartment so they may be serviced during operation of the equipment. The compressor shall be semi-hermetic with a suction gas cooled motor, vibration isolators, thermal overloads, oil sight glass, manual reset high pressure switch, pump down low pressure switch, suction line strainer, reversible oil pumps for forced feed lubrication, and a maximum operating speed of 1750 RPM.

G. The compressors shall include the optional multi-Step refrigeration system. The environmental control system shall include cylinder unloaders on the semi-hermetic compressors. The unloaders shall be activated by solenoid valves which are controlled from the microprocessor control. In response to the return air temperature, the microprocessor control shall activate the unloader solenoids and the liquid line solenoids such that four stages of refrigeration cooling are obtained. The stages shall be 1) one compressor partially loaded, 2) two compressors partially loaded, 3) one compressor partially loaded and one compressor fully loaded, and 4) two compressors fully loaded. On call for dehumidification, the microprocessor shall insure that at least one compressor is on fully for proper humidity control.

H. Each refrigeration circuit shall include hot gas mufflers, liquid line filter dryers, refrigerant sight glass with moisture indicator, adjustable, externally equalized expansion valves, and liquid line solenoid valves.

I. The evaporator coil shall be an A-Frame design constructed of 4 rows of copper tubes and aluminum fins and shall have a maximum face velocity of 510 ft. per minute, with a face area of 29.4 sq. ft. Refrigerant of each system shall be distributed throughout the entire coil face area. A stainless steel condensate drain pan shall be provided.

J. Unit shall be equipped with the following optional components:

1. Non-Locking Disconnect Switch. The manual disconnect switch shall be mounted in the high voltage section of the electrical panel. The switch shall be accessible with the door closed.
2. Liqui-Tect 460-Z45 Zone Water Detection Kit. Kit shall consist of 45’ of liquid sensing cable to surround the unit and shall provide alarm and unit shutdown capabilities. The unit Advanced Microprocessor control system shall be factory configured for the “water under floor” alarm input from the Liqui-Tect sensing device.
3. Smoke Detector. The unit shall include a factory mounted and wired smoke detector in the unit capable of immediately shutting down the system upon sensing smoke and communication with building fire alarm system. The smoke detector shall be mounted in the electrical panel with the sensing element in the return air compartment.
4. Site Link Interface. Unit shall be provide and factory installed with all appropriate interfaces for communication to the SiteLink. All CRAC units to be factory configured to enable read/write communication with the existing Building Automation System via the SiteLink using Modbus RTU Protocol.

5. Floor stand and optional turning vane.

2.3 AIR COOLED CONDENSER

A. The air cooled condenser shall be the low profile, slow speed type with four direct drive propeller fans. The condenser shall have two separate refrigeration circuits to balance the heat rejection of each compressor. The casing shall be constructed of aluminum and shall contain a copper tube, aluminum fin coil arranged for horizontal discharge.

B. Winter control system shall be by variable Fan Speed Control and designed with ball bearings, permanent lubrication, internal overload protection, 40 deg. C rise at full speed, 65 deg. C rise at 10 rpm. The unit shall be rated for 105 deg. ambient operating temperature.

C. The control system shall be complete with transducers, thermostats and electrical control circuit, factory pre-packaged in the integral condenser control box. Transducer shall automatically sense the highest head pressure of either operating compressor and control the variable speed fan on the air cooled condenser to properly maintain the head pressure. The fan speed control system shall provide positive start-up and operation in ambient temperature as low as -20 deg. F.

2.4 CONTROL SYSTEM

A. The unit shall be equipped with the Advanced Microprocessor control system. The system shall be microprocessor based with a front monitor LCD display panel and control keys for user inputs. The controls shall be menu driven with on-screen prompts for easy user operation. The system shall allow user review and programming of temperature and humidity setpoints, alarm parameters, and setup selections including choice of control type. A password shall be required to make system changes. For all user selections, the range of acceptable input (temperature, humidity, or time delay) shall be displayed on the monitor screen. The system shall provide monitoring of room conditions, operational status in % of each function, component run times, date and time, and four analog inputs from sensors provided by others.

B. The control system shall allow programming of the following room conditions:

Temperature Setpoint 65-85°F (18-29°C)
Temperature Sensitivity ±1° to 9.9°F (0.6 to 5.6°C) in 0.1°F (.1°C) increments
Humidity Setpoint 20-80% R.H.
Humidity Sensitivity +1% to +30% R.H.

C. All setpoints shall be adjustable from the individual unit front monitor panel. Temperature and Humidity Sensors shall be capable of being calibrated using the front monitor panel controls to coordinate with other temperature and humidity sensors in the room.

D. Compressor Short-Cycle Control. The control system shall include a program to prevent compressor short cycling.

E. Automatic Compressor Sequencing. The microprocessor shall automatically change the lead/lag sequence of the compressors after each start to lengthen compressor-on cycles and even compressor wear.

F. System Auto-Restart. For start-up after power failure, the system shall provide automatic restart with a programmable (up to 9.9 minutes in 6-second increments) time delay. Programming can be

performed either at the unit or from the central site monitoring system.

G. Sequential Load Activation. During start-up, or after power failure, the microprocessor shall sequence operational load activation to minimize inrush current. Systems allowing multiple loads to start simultaneously are unacceptable.

H. Monitor Display Panel. The microprocessor shall provide a front monitor LCD backlit display panel with 4 rows of 20 characters with adjustable contrast. This display (along with five front mounted control keys) shall be the only operator interface required to obtain all available system information such as room conditions, operational status, alarms, control and alarm setpoints, and all user selections including alarm delays, sensor calibration, DIP switch selections, and diagnostics. All indicators shall be in language form. No symbols or codes shall be acceptable.

I. Alarms. The microprocessor shall activate an audible and visual alarm in event of any of the following conditions:

High Temperature
Low Temperature
High Humidity
Low Humidity
Short Cycle
Compressor
Overload (#1 and #2) (opt)
Main Fan Overload (opt)
High Head Pressure (#1 and #2)
Change Filters
Loss of Air Flow
Low Suction Pressure
Loss of Power
Custom Alarm (#1 to #4)

Custom alarms are four customer accessible alarm inputs to be indicated on the front panel. Custom alarms can be identified with prepared (programmed) labels for the following frequently used inputs:

Water Under Floor
Smoke Detected
Standby Unit On

User customized text can be entered for two of the four custom alarms. Each alarm (unit and custom) can be separately enabled or disabled, selected to activate the common alarm, and programmed for a time delay of 0 to 255 seconds.

J. Audible Alarm. The audible alarm shall annunciate any alarm that is enabled by the operator.

K. Common Alarm. A programmable common alarm shall be provided to interface user selected alarms with a remote alarm device.

L. Remote Monitoring Provide SiteLink using Modbus RTU Protocol for communication with up to 12 interface control modules. Factory start up and configuration of SiteLink must be coordinated with BAS contractor for integration of SiteLink with existing building control system.

M. Control Type. The user shall be able to select the type of control the advanced microprocessor will use. Selections available shall be intelligent, proportional, and tunable PID (proportional, integral, and derivative gains). The intelligent control shall incorporate control logic that uses artificial intelligence techniques including "fuzzy logic" and "expert systems" methods to maintain precise, stable control. If tunable PID is selected, the user shall be able to program each of the three gains.

N. Diagnostics. The control system and electronic circuitry shall be provided with self-diagnostics to aid in troubleshooting. The microcontroller board shall be diagnosed and reported as pass/not pass. Control inputs shall be indicated as on or off at the front monitor panel. Control outputs shall be able to be turned on or off from the front monitor panel without using jumpers or a service terminal.

O. Data Collection. The control system shall maintain accumulative operating hours of compressors, reheats, humidifier, fan motor and Econ-o-coil. The ten most recent alarms shall also be retained.

P. Communications. The microprocessor shall be compatible with all Liebert remote monitoring and control devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Connect refrigerant, water and drain piping to offer least resistance to airflow.

B. Interconnect indoor and outdoor sections with refrigerant piping and electrical power and control wiring per manufacturer's recommendations.

3.2 START-UP

A. Provide start-up and basic operator training of equipment by factory trained personnel.

END OF SECTION 23 81 23

SECTION 23 81 24 - HIGH DENSITY DATA CENTER IN-ROW COOLING SYSTEM

PART 1 – GENERAL

1.1 SUMMARY

These specifications describe requirements for an air conditioning system designed for cooling of high heat density equipment. The system shall be designed to maintain conditions within the space with heat emitting equipment. The manufacturer shall design and furnish all equipment to be fully compatible with heat dissipation requirements of the site.

1.2 DESIGN REQUIREMENTS

The air conditioning system shall be a factory-assembled unit. The unit shall be designed for draw-through air arrangement to ensure even air distribution to the entire face area of the coils.

1.3 SUBMITTALS

Submittals shall be provided with the proposal and shall include: Dimensional, Electrical and Capacity data; typical Piping and Electrical Connection.

1.4 WARRANTY

Provide a 5 year part and labor (bumper-to-bumper), no item is excluded) warranty for each unit.

1.5 QUALITY ASSURANCE

The specified system shall be factory-tested before shipment and designed to meet NRTL requirements. The system shall be designed and manufactured according to world-class quality standards. The manufacturer shall be ISO 9001 certified.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Liebert Corporation

B. APC

2.2 COOLING MODULES

A. Module shall include micro channel DX cooling coils and fans housed in a cabinet.

B. Refrigerant shall be supplied to the cooling modules from a Pumping Unit to prevent coil condensation and optimize the refrigerant temperature to the cooling module.

C. Each module shall consist of six (6) axial fans with finger guards.

D. Each module shall be equipped with two (2) permanent, primary and secondary, attached connectors to the rear of the unit.

E. Factory-installed piping shall be leak-tested and pressure-tested prior to shipment from the factory.

F. Each module shall have dual power cords with automatic switching.

G. Provide each unit with factory-installed control boards and condensate detection for the drip pan. The module shall have connection points (dry contacts) in the electrical box for connection of outgoing alarm cables for condensate detection, fan failure and for remote shutdown.

H. Unit shall be provided with different front air discharge diffusers; for front air discharge to both sides or for front air discharge to one side, as required by rack layout.

2.3 DX CHILLED WATER PUMPING UNIT

A. The unit shall include a heat exchanger, pumps, microprocessor control, modulating control valve, disconnect switch and associated factory-installed piping.

B. The components shall be enclosed in a cabinet with powder painted doors. Two (2) doors shall hinge from the front for service access.

C. The pumps shall be factory-piped and factory-wired in the pumping unit module.

D. The heat exchanger shall be brazed-plate type, constructed of 316 stainless-steel plates. The primary side shall be piped to a chilled water source and the secondary side refrigerant circuit shall be piped to cooling module(s). A strainer shall be installed upstream of the heat exchanger, on the primary (building) chilled water side.

E. A modulating, two-way chilled water valve shall control the flow of chilled water on the primary side of the heat exchanger. The valve actuator shall respond to changes in room dew point temperature to control the supply temperature for optimum cooling with no condensation.

F. The control shall be factory-set for Intelligent Control which uses “fuzzy logic” and “expert systems” methods. Proportional and Tunable PID shall also be user selectable options. Internal unit component control shall include the following:

1. System Auto Restart - The auto restart feature will automatically restart the system after a power failure. Time delay is programmable.
2. Sequential Load Activation - On initial startup or restart after power failure, each operational load is sequenced with a minimum of one second delay to minimize total inrush current.
3. System View - Status Overview: “System View” shall display a summary of operation for the total number of operating units within a Unit-to-Unit (U2U) configuration.
4. Spare Parts List: Menu shall include a list of critical spare parts, their quantity and part numbers.
5. Unit Diary - Menu shall include a free field area within the unit memory where unit history may be stored for reference.

The control shall be compatible with all remote monitoring control devices and capable of for BMS interface via MODbus or BACNet to building automation.

The control processor shall be microprocessor based with a 320x240 dot matrix graphic front monitor display and control keys for user inputs mounted in an ergonomic, aesthetically pleasing housing. The display & housing shall be viewable while the unit panels are open or closed. The controls shall be menu driven. The display shall be organized into three main sections: User Menus, Service Menus and Advanced Menus. The system shall display user menus for: active alarms, event log, graphic data, unit view/status overview (including the monitoring of room conditions, operational status in % of each function, date and time), total run hours, various sensors, display setup and service contacts. A password shall be required to make system changes within the service menus. Service menus shall include: setpoints, standby settings (lead/lag), timers/sleep mode, alarm setup, sensor calibration, maintenance/wellness settings, options setup, system/network setup, auxiliary boards and diagnostics/service mode. A password shall be required to access the advanced menus which include the factory settings and password menus.

G. The User Menus Shall be Defined as Follows:

1. Active Alarms: Unit memory shall hold the 200 most recent alarms with time and date stamp for each alarm.
2. Event Log: Unit memory shall hold the 400 most recent events with id number, time and date stamp for each event.
3. Graphic Data View: Eight graphic records shall be available: return air temperature, return air humidity, supply air temperature, outdoor temperature and four custom graphs.
4. Unit View - Status Overview: Simple or Graphical “Unit View” summary displays shall include temperature and humidity values, active functions (and percent of operation) and any alarms of the host unit.
5. Total Run Hours: Menu shall display accumulative component operating hours for major components.
6. Service Contacts: Menu shall allow display of local service contact name and phone number.

H. The Service Menus Shall be Defined as Follows:

1. Setpoints: Menu shall allow setpoints within the following ranges:

   Minimum Room Temperature Setpoint 50-80ºF

2. Alarm Setup: Menu shall allow customer settings for alarm notification (audible/local/remote). The following alarms shall be available:
   - High Room Temperature
   - Low Room Temperature
   - High Dew Point
   - High Refrigerant Temperature
   - High Chilled Water Temperature
3. Audible Alarm: The audible alarm shall annunciate any alarm that is enabled by the operator.
4. Common Alarm: A programmable common alarm shall be provided to interface user selected alarms with a remote alarm device.
5. Remote Monitoring: All alarms shall be communicated to the unit monitoring system with the following information: Date and time of occurrence, unit number and present temperature and humidity.
6. Sensor Calibration: Menu shall allow unit sensors to be calibrated with external sensors.
7. Maintenance/Wellness Settings: Menu shall allow reporting of potential component problems before they occur.

8. Options Setup: Menu shall provide operation settings for the installed components.
9. Auxiliary Boards: Menu shall allow setup of optional expansion boards.
10. Diagnostics/Service Mode: The control shall be provided with self-diagnostics to aid in troubleshooting. The microcontroller board shall be diagnosed and reported as pass/not pass. Control inputs shall be indicated as on or off at the front display. Control outputs shall be able to be turned on or off from the front display without using jumpers or a service terminal. Each control output shall be indicated by an LED on a circuit board.

2.4 ADVANCED MENUS

A. Factory Settings: Configuration settings shall be factory-set based on the pre-defined component operation.

B. Change Passwords: Menu shall allow new passwords to be set or changed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install the unit in accordance with the manufacturer’s installation instructions. Maintain recommended service clearances as outlined in the installation instructions.

B. Furnish copy of manufacturer’s electrical connection diagram submittal to the electrical contractor.

C. Install and connect devices furnished by the manufacturer but not specified to be factory-mounted. Furnish a copy of the manufacturer’s piping connection diagram submittal to the contractor.

D. Connect supply and return piping from the pumping unit to cooling modules.

3.2 STARTUP

A. Start up the air conditioning unit in accordance with the manufacturer’s startup instructions. Test controls and demonstrate compliance with requirements.

END OF SECTION 23 81 24

SECTION 23 81 26 - AIR COOLED SPLIT SYSTEM AIR CONDITIONING UNIT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Factory Built Split System Air Conditioning Unit.

B. Internal Piping and Accessories.

C. Controls.

1.2 SUBMITTALS

A. Submit manufacturer's product data including:

1. Dimensional data.
2. Cross plot of condenser with its associated evaporator showing sensible and total capacities at scheduled conditions.
3. Electrical power and control wiring diagrams.
4. Electrical characteristics.
5. Installation instructions.
6. Piping connection location and sizes.
7. Maintenance and operating manuals.

1.3 QUALITY ASSURANCE

A. Conform to requirements of UL and applicable codes.

B. Test and rate cooling systems to ARI Standard 210.

C. Test and rate sound of Outdoor Unitary Equipment to ARI-270.

1.4 WARRANTY

A. Provide a warranty covering all parts and labor for one year from date of start-up. Compressors shall have minimum warranty of five years from date of start-up.

1.5 REGULATORY REQUIREMENTS

A. Conform to NFPA 70 and Energy Conservation Standard for New State Office Buildings. Refer to Table 10-5 for Room Air Conditioning Limits and Table 10-1 for Split Systems.

B. Provide certificate from manufacturer(s) indicating compliance with State Energy Code efficiency requirements for packaged terminal air conditioning units and room air conditioners.

C. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories, Inc., testing firm acceptable to the Authority Having Jurisdiction as suitable for the purpose specified and indicated.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Carrier.

B. Daikin Applied.

C. Trane.

2.2 TYPE AND PERFORMANCE

A. Provide self-contained, packaged, factory assembled and prewired Dx condensing units suitable for outdoor use (consisting of cabinet, compressors, condensing coil and fans) and packaged air handler with DX coil (consisting of integral subcooling coil, fans, controls, liquid receiver and screens).

B. The condensing unit and associated air handling unit shall be the product of one manufacturer and shall meet or exceed the capacity scheduled on the drawings. Ratings shall be in accordance with ARI 210/240 and ANSI/UL 207 and ANSI/UL 303. Testing shall be in accordance with ASHRAE 14. Energy Efficiency Rating (EER) and Coefficient of Performance (COP) not less than prescribed by ANSI/ASHRAE 90A.

2.3 MATERIALS (CONDENSING UNIT)

A. Use corrosion resistant materials for parts in contact with refrigerant.

B. Provide timer circuits to prevent rapid loading and unloading of compressor.

2.4 CABINET (CONDENSING UNIT)

A. Galvanized steel with baked enamel finish and removable access doors or panels with quick fasteners. Cabinet shall incorporate louvered panels (i.e. hail guard) or other design feature to protect condensing coil.

2.5 COMPRESSOR (CONDENSING UNIT)

A. Compressor shall be either scroll type construction or hermetic reciprocating type with heat treated forged steel or cast iron shafts, aluminum alloy connecting rods, automotive type pistons, rings to prevent gas leakage, suction and discharge valves, and sealing surface immersed in oil.

B. Mounting: Statically and dynamically balanced rotating parts, mounted on spring vibration isolators.

C. Lubrication System: Reversible, positive displacement oil pump with oil charging valve, oil level sight glass, oil filter, and magnetic plug or strainer.

D. Compressors shall be warranted for five years from date of Certification of Substantial Completion.

2.6 CONDENSER (CONDENSING UNIT)

A. Coil: Seamless copper tubing with mechanically bolded aluminum fins. Provide sub-cooling circuits.

B. Fan: Vertical discharge direct drive propeller fan resiliently mounted with fan guard on discharge, and ball bearings with grease fittings extended to outside of casing.

C. Motors: Permanently lubricated ball bearing motors with built-in current and overload protection, U.L. listed for outdoor use, complete with large rain guard shields.

2.7 CONTROLS

A. Starters, disconnects and controls shall be mounted in a weatherproof panel with full opening access doors.

B. Provide 24 Volt transformers for controls as required.

C. On unit, mount weatherproof steel control panel, NEMA 250, containing power and control wiring, factory wired with single point power connection.

D. For compressor, provide starter, non-recycling compressor overload, starter relay, and control power transformer or terminal for controls power. Provide manual reset current overload protection. For condenser fan, provide across-the-line starter with starter relay.

E. Provide the following safety controls arranged so that operating any one will shut down machine and require manual reset:

1. High discharge pressure switch (manual reset).
2. Low suction pressure switch (automatic reset).
3. Oil pressure switch (manual reset).

F. Provide controls including hot gas bypass, if required, to permit operation down to 0 degrees F. ambient temperature at minimum compressor load.

G. Provide space thermostat with each unit.

2.8 EVAPORATOR (AIR HANDLER)

A. Evaporator Section:

1. Fan for the evaporator shall be belt driven with adjustable sheaves or direct driven double width/double inlet forward curved centrifugal fan statically and dynamically balanced, resiliently mounted. Provide manually adjustable speed controls mounted on the fan housing for direct drive models.

B. Evaporator Coil:

1. Direct expansion cooling coil of seamless copper expanded into aluminum fins.
2. Coil shall drain into an insulated drain pan.

3. Refrigeration circuit with externally equalized thermal expansion valve, filter-drier, and charging valves.

2.9 REFRIGERANT CIRCUIT

A. Provide unit with one refrigerant circuit factory supplied and piped. Entire system shall conform to state and federal quidelines for refrigerant characteristics.

B. Provide the following for each refrigerant circuit:

1. Filter dryer.
2. Liquid line sight glass and moisture indicator.
3. Expansion valve for maximum operating pressure, per manufacturer.
4. Insulated suction line.
5. Suction and liquid line service valves.
6. Liquid line solenoid valve.
7. Charging valve.
8. Discharge line check valve.
9. Compressor discharge service valve.
10. Condenser pressure relief valve.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide mechanical and electrical connections in accordance with manufacturer's installation instructions.

B. Furnish charge of refrigerant and oil.

3.2 START-UP AND TESTING

A. Supply initial charge of refrigerant and oil for each refrigeration system. Replace losses of oil or refrigerant prior to end of correction period.

B. Test entire refrigeration piping system for leaks and repair leaks.

C. Shut-down system if initial start-up and testing take place in winter and machines are to remain inoperative. Repeat start-up and testing operating at beginning of first cooling season.

D. Provide cooling season start-up and winter season shut-down for first year of operation.

END OF SECTION 23 81 26

SECTION 23 82 16 - AIR COILS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Chilled Water Coils.

B. Hot Water Heating Coils.

C. Direct Expansion (Dx) Cooling Coils

D. Electric Heating Coils.

1.2 SUBMITTALS

A. Submit materials, dimensional and performance data.

B. Submit manufacturer's installation instructions.

C. Submit manufacturer's descriptive literature, operating instructions, and maintenance and repair data.

D. Submit computerized or manual coil selection calculations showing sensible and total capacity, flow rates, air side pressure drop, water side pressure drop, tube velocity, tube rows and fins per inch, etc.

1.3 QUALITY ASSURANCE

A. Certify coil capacities, pressure drops and selection procedures in accordance with ARI Standard 410.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Heatcraft

B. Carrier.

C. Daikin Applied.

D. Trane.

2.2 PERFORMANCE

A. Coil performance shall meet or exceed the scheduled capacity, at fluid flows and pressure drops not exceeding scheduled values.

2.3 DESIGN AND CONSTRUCTION

A. Coils shall be independently removable without affecting the structural integrity of the air handling unit casing. Coil frames shall not be a part of the air handling unit structural frame.

B. Coil inlet and outlet connections shall be threaded and shall be on the same side of the unit. Connections shall extend not less than 4" beyond unit casing. Connections of copper construction shall have wrench flats.

C. Coils shall have air vent connection at high point and drain connection at low point extended through the unit casing.

D. Coils shall be tested by air pressure under water. Heating and chilled water coils shall be designed for 150 psi and 200 degrees F working conditions. Coils shall be tested at one and one-half times the specified working pressure classification or as otherwise indicted on the riser diagrams or equipment schedules. The test pressure shall, in no case, be less than 225 psig, nor more than 450 psig.

E. Heating and chilled water coils shall be extended surface type with 1/2" or 5/8" diameter tubes of copper or brass, and plate fins of aluminum, mechanically bonded to tubes. Headers shall be copper or cast iron construction with threaded carbon steel, brass, or soldered copper connections. Spiral fins are not acceptable. Coils shall be designed without "enhanced" water flow circuiting. Waterflow velocities at design coil conditions shall be greater than 2.7 feet/second while not exceeding 8 feet/second. Unless otherwise scheduled on contract drawings, maximum water pressure drop shall not exceed 15 feet w.g. at design conditions.

F. Cooling coils shall have minimum 16 gauge stainless steel casings with intermediate tube sheets 48 inches on center maximum. Stacked coils shall have stainless steel intermediate drain pans with copper downspouts extended to main drain pan.

G. Cooling & heating coil ratings shall be in accordance with ARI Standard 410 certified data, except capacity shall meet capacities scheduled on contract documents without any design tolerance.

H. Chilled Water Cooling Coils:

1. Maximum 12 fins/inch with 6 row coil or 10 fins/inch with 8 row coil (unsplit)
2. Stainless Steel Drainpans
3. Stainless Steel Casings
4. Split cooling coil when 8 rows or greater are required where shown on construction documents.
5. Headers shall be copper or cast iron with threaded connections. Tubes shall be minimum 0.026. Tube bends shall be minimum 0.035 inch. Fin thickness shall be 0.0075 inch for aluminum

I. Heating Water Coils:

1. Minimum 6 fins/inch, maximum 12 fins/
2. Galvanized Steel Casings
3. Headers shall be copper or cast iron with threaded connections. Tubes shall be minimum 0.026. Tube bends shall be minimum 0.035 inch. Fin thickness shall be 0.0075 inch for aluminum

J. Direct Expansion (DX) Cooling Coils:

1. Minimum 5/8 inch O.D. tubes and 0.035” wall construction with mechanically bonded aluminum plate fins.
2. Stainless steel drainpan
3. Copper solder type connections.
4. Minimum of two pressure type distributors with intertwined row split circuiting.
5. Stainless steel coil casing.
6. Dehydrated and charged with dry nitrogen.
7. Maximum 12 fins/inch and 6 rows.

K. Electric Heating Coils:

1. Electric heat of capacity and steps specified shall be provided as an integral part of the unit. Field installed sections shall not be acceptable. The electric heater and control panel shall be a UL listed electric duct heater.
2. Open type 80% nickel, 20% chromium wire.
3. Coil elements shall float freely in ceramic bushings which are staked in support brackets, not exceeding 3-1/2" apart.
4. Coils shall be machine crimped into stainless steel terminals which are insulated with high temperature ceramic insulators.
5. Panel enclosure shall be of NEMA 1 construction for indoor units and NEMA-4 for outdoor units and shall contain all terminals, contactors, controls and fuses as specified. The panel, elements and all wiring shall be contained in the unit mounted control panel.
6. Coils shall be provided with the following safety options:

    a. Primary over-temperature protection shall be by two automatic reset thermal cut-outs. A disc type located in the top flange near terminal box.
    b. Secondary independent over-temperature protection shall be by means of a manual reset disc cut-out located in the base of the terminal box in series with each heater circuit. This device de-energizes the heater circuit.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Cooling coils shall be provided with drip pan and drain connection for each field assembled coil section. Fabricate drain pan from stainless steel. Extend 3 inches from face of coil on entering air side, 6 inches from face of coil on leaving air side. Provide intermediate drain pans with downspouts for coil sections more than one coil high.

B. Support coil sections on steel channel or double angle frames and secure to casings. Arrange supports for cooling coils to avoid piercing or short circuiting drip pans. Bolt casings to other section, ductwork, or unit casings. Provide airtight seal between coil and duct or unit cabinets.

C. Chilled water cooling coil shall be six (6) rows deep, but shall be more rows if required to meet or exceed the specified design load for the sensible heat removal requirements as well as the total heat removable. Coils more than six rows deep shall be separated into two banks of coils with space in between for cleaning, unless shown otherwise on contract drawings

D. Make connections to coils, including valves, air vents, unions, and connections from drip pans. Provide shut off valve on supply piping connection and balancing valve on return line from each water coil. Arrange piping and provide unions or flanges to facilitate coil pull without dismantling major piping.

E. Locate water supply connection at bottom of supply header and return water connection at top of header for chilled water and at top of supply header and bottom of return header for hot water to provide self-venting and reverse return arrangement. Provide float operated automatic air vents at high points complete with stop valve. Ensure water coils are drainable and make drain connection at low points.

F. Protect coils so fins and flanges are not damaged. Replace loose and damaged fins. Comb out bent fins.

G. Level serpentine coils and install cleanable tube coils and steam coils with 1:50 pitch.

H. Install vacuum breaker in steam line at header, or in header.

I. Provide properly sized thermostatically controlled expansion valve for direct expansion coils designed to meet scheduled capacity.

END OF SECTION 23 82 16