REQUEST FOR PROPOSALS

WORTHAM BUILDING AUTOMATION SYSTEM UPGRADE

HOUSTON FIRST CORPORATION

MAY 13, 2014

WORTHAM BUILDING AUTOMATION SYSTEM UPGRADE

ISSUE DATE:	May 13, 2014
PROPOSALS DUE:	**1:00 P.M.** on **June 30, 2014** ("Submission Deadline")
INSTRUCTIONS:	Proposers must submit ten (10) signed hard copies of their proposal plus one electronic copy submitted on a CD or a flash drive of their response in a sealed envelope in person, via mail or courier. Proposals received by email or fax will be rejected.
SUBMIT TO:	Lisa Hargrove, General Counsel, Houston First Corporation, Administration Office, 1001 Avenida de las Americas, Houston, TX 77010. The project name should be clearly visible on the outside of the envelope.
CONTACT INFO:	Any questions concerning this Request for Proposals ("RFP") must be sent by e-mail to **bids@houstonfirst.com**. Questions must be received no later than **noon** on **June 20, 2014**.

RFP PACKETS
All persons and entities interested in responding to this RFP ("Proposers") are advised that a complete copy of this RFP, including the Scope of Services, Standard Contract Terms, and all necessary information are available on-line at **www.houstonfirst.com/DoBusiness.aspx**.

PRE-PROPOSAL CONFERENCE
A pre-proposal conference will be held for all prospective Proposers at **10:00 a.m.** on **June 17, 2014** in the Texas Lobby at the Wortham Theater Center, located at 501 Texas Ave, Houston, TX 77002. All Proposers are urged to be present.

LETTERS OF CLARIFICATION
Any revisions to be incorporated into this RFP will be confirmed in a written letter to all potential respondents ("Letter of Clarification") prior to the submission deadline. When issued by Houston First Corporation, Letter(s) of Clarification shall automatically become part of this RFP and shall supersede any previous specifications or provisions in conflict therewith. By submitting a response, Proposers shall be deemed to have received all Letters of Clarification and to have incorporated them into their proposal. Verbal responses will not otherwise alter the specifications, terms and conditions as stated herein. It is the responsibility of each Proposer to monitor **www.houstonfirst.com/DoBusiness.aspx** to ensure they receive any such Letter(s) of Clarification.

BACKGROUND
HFC is a local government corporation created by the City of Houston to facilitate economic growth through the business of conventions and the arts. HFC is responsible for management and operation of more than 10 city-owned buildings and plazas, and underground and surface parking for nearly 7,000 vehicles. Facilities include the George R. Brown Convention Center, Jones Hall, Wortham Theater, Miller Outdoor Theatre, Talento Bilingue de Houston, Houston Center for the Arts, and certain outdoor facilities such as Jones Plaza, Sesquicentennial Park, Ray C. Fish Plaza, Root Memorial Square, and several other small landscaped properties.

RESPONSE FORMAT
Although HFC prefers substance over form, proposers should include the following information in their proposal:

a. **Transmittal Letter:** Include a brief cover letter signed by a person authorized to make representations on behalf of the Proposer. Please include a direct phone number and email address for such authorized individual. Make a specific statement agreeing to comply with the terms and conditions of the RFP (or identify any objections/exceptions with specificity).

b. **Profile:** Detail Proposer's history, methods, and strengths at meeting the needs of its clients. Indicate availability for the Project date and disclose any other projects Proposer intends to undertake during such time.

c. **Experience:** Discuss Proposer's specific experience, both previous and current, completing stage rigging projects at comparable facilities. Provide at least three references, including contact names, phone numbers, and a brief description of the work completed by Proposer.

d. **Key Personnel & Diversity:** Describe the background and experience of the personnel who will be assigned to the Project and a brief summary of their qualifications. Note sub-consultants reasonably expected to be used and identify any Minority and/or Women-owned Business Enterprises or Historically Underutilized Businesses.

e. **Costs:** Identify all direct and indirect costs and expenses that will or may be charged to HFC to complete the Project. A model form is set forth below.

f. **Value Added Services** (Optional): Proposers are encouraged, but not required, to recommend additional or alternative services, specifications, or solutions to accomplish or enhance the objectives outlined in the Scope of Services.

MANNER OF SELECTION
HFC intends to make a selection and enter into a contract with the best-qualified Proposer based on merit and qualifications. Factors HFC will consider include, but are not limited to, experience, personnel, references, diversity commitment, and overall responsiveness to this solicitation. HFC reserves the right to schedule oral interviews with some or all Proposers prior to making a final selection. This RFP does not commit HFC to award a contract, issue a purchase order, or to pay any costs incurred in the preparation of a proposal in response to this RFP. HFC reserves the right to select or reject all or part of any proposal, waive minor technicalities, cancel the process, and select offers in the manner and to the extent that they serve the best interests of HFC.

FORM OF AGREEMENT
By submitting a response to this solicitation, Proposer agrees, upon notice of selection by HFC, to enter into an agreement which will include, but not be limited to, the terms and conditions set forth in the Standard Contract Terms below. If Proposer takes exception to any portion of the terms and conditions, then such Proposer shall submit a list of such exceptions as part of its response to this solicitation; provided, however, that HFC reserves the right to reject responses including substantive objections without further review or consideration.

PUBLIC INFORMATION
As HFC is subject to the Texas Public Information Act ("TPIA"), all information submitted by Proposers is subject to release under the provisions of the TPIA set forth in Chapter 552 of the Texas Government Code. Each page where confidential or proprietary information appears must be labeled as such clearly and unambiguously. Proposers will be advised of any request for public information that implicates their materials and will have the opportunity to raise objections to disclosure with the Texas Attorney General at their cost and expense.

RESTRICTIONS ON COMMUNICATIONS
From the date issued until the Submission Deadline, proposers are directed not to communicate with HFC officers, directors or employees regarding any matter relating to this RFP, other than **bids@houstonfirst.com** and HFC representatives during the pre-proposal conference. HFC reserves the right to reject any proposal due to violation of this provision.

COLLUSION
The Proposer represents that the contents of its proposal have not been communicated, directly or indirectly, to any potential proposer and that its proposal is made in compliance with federal and state antitrust laws without previous understanding, agreement or connection with any competitor or other potential proposer.

CONFLICT OF INTEREST
Proposers are required to disclose any affiliation or business relationship that might cause a conflict of interest with HFC. The required disclosure form is available online at: http://www.ethics.state.tx.us/forms/CIQ.pdf. By submitting a proposal, Proposers represent that they are in compliance with the requirements of Chapter 176 of the Texas Local Government Code.

BONDS
The Proposer selected shall be required to execute a payment bond and performance bond on forms approved by HFC. A bid bond is not required.

PRICING FORM

Proposers are required to provide specific prices in the spaces provided below. Houston First Corporation encourages proposers to suggest and offer additional pricing for enhancements to this project.

BASE BID _____
(lump sum)

ALTERNATE #1: UPGRADE OF 3 CHILLERS CONTROL PANELS _____
(lump sum, in addition to base bid)

ALTERNATE #2: CENTRAL PLANT OPTIMIZATION _____
(lump sum, in addition to base bid)

VOLUNTARY BID ALTERNATES _____
(optional lump sum, indicated as + or – base bid)

VOLUNTARY BID ALTERNATES _____
(optional lump sum, indicated as + or – base bid)

TOTAL OF BASE BID AND ALL ALTERNATES _____

STANDARD CONTRACT TERMS

By submitting a proposal, the Proposer agrees to incorporate all of the following standard contract terms as part of any agreement with HFC arising out of the Project.

1.0 Project

1.1 Contractor agrees to and shall complete the Project in strict accordance with this Agreement, the Specifications, and the Construction Terms & Conditions.

1.2 The name of the project is the **Wortham Building Automation System Upgrade** ("Project"). The location of the Project is the Gus. S. Wortham Theater Center, located at 500 Texas Ave., Houston, Texas 77002 ("Facility").

1.3 The Facility is owned by the City of Houston, Texas and subject to a long-term lease to HFC. **CONTRACTOR AND HFC ACKNOWLEDGE AND AGREE THAT THE PROJECT AND ALL WORK RELATED THERETO CONSTITUTE AND SHALL BE CONSIDERED TO BE A PUBLIC WORKS PROJECT OF A MUNICIPALITY FOR ALL PURPOSES, INCLUDING CHAPTER 151 OF THE TEXAS INSURANCE CODE.**

1.4 HFC has retained **Redding Linden Burr, Inc.** ("Engineer") to perform professional architectural services relating to the Project. Engineer's contact information is as follows: Stephen M. Redding, 801 Travis St., Ste. 2000, Houston, TX 77002. Tel. 713-237-9800 ext. 149. Email: sredding@rlbengineers.com.

2.0 Time for Completion

2.1 Contractor agrees to and shall commence Work upon receipt of notice to proceed from HFC and shall complete the Project within **120 calendar days** ("Contract Time") subject to adjustments, if any, in accordance with the Contract Terms & Conditions.

3.0 Payment

3.1 HFC agrees to pay Contractor [TBD] ("Contract Sum"). No more than once every thirty (30) calendar days, Contractor may request a progress payment from HFC based on the quantity of work completed. HFC may approve, deny, or adjust such request in its sole, but reasonable discretion. In no event shall HFC pay Contractor more than **85%** of the Contract Sum prior to Final Completion of the Project and approval by HFC.

4.0 Work Conditions and Restrictions

4.1 All work performed by the Contractor shall be in accordance with the latest City of Houston Building and Electrical Codes.

4.2 Electricians employed by Contractor or its subcontractors must be licensed by the Texas Department of Licensing and Regulation.

4.3 Contractor shall on a daily basis or as requested by HFC or Engineer, clean the work site and any adjacent areas affected by the Project.

4.4 Contractor shall take precautions to minimize disruption of events at the Facility to minimize dust, noise, and fumes, and to prevent power outages or the disturbance of utilities, fire suppression equipment, plumbing systems, and any other equipment or systems connected to the Facility.

4.5. The manner and extent to which Contractor may use common areas of the facility, including, but not limited to, entrances and loading docks, shall be determined by HFC in its sole discretion.

4.6 Contractor shall protect all areas and equipment when working in the facility. All carpeted floor areas must be protected with plastic and/or cardboard, for the duration of the Project. Caution warning signs shall be placed near any slippery or wet surfaces. Contractor shall be responsible for the cost of repairing any carpet damage caused by the negligence of Contractor, its subcontractors or agents. In addition, the Contractor will be held responsible for damage to elevators, doors, or other facility finishes, or other equipment caused by the negligence of Contractor, its subcontractors or agents. Damage, as used in this Section, shall not include normal wear and tear. Repairs and replacements of such items and finishes may be deducted from Contractor's fees.

4.7 Contractor shall on a daily basis or as requested, clean the work sites and any adjacent areas affected by the Project.

4.8 Contractor is solely responsible for any necessary permits to complete the work.

5.0 Warranties and Representations

5.1 Contractor shall provide HFC with a two-year warranty on all goods, materials, any reused wiring, and equipment in accordance with the terms and conditions of the Contract.

5.2 Warranty periods shall commence the date on which HFC approves Final Completion of the Project.

5.3 All work shall be performed and completed in a thorough, workmanlike manner in accordance with industry standards and best practices by skilled and experienced workers.

5.4 Contractor shall transfer to HFC any manufacturer's warranties which it has for materials used in connection with this Project.

5.5 Contractor represents that it is duly formed, validly existing and in good standing under the laws of the State of Texas.

6.0 Safety

6.1 Contractor represents and warrants that services performed by Contractor shall conform to the standards declared by OSHA, including, but not limited to, compliance with federal and state safety standards/directives for setting-up and utilizing platforms, lifts, ladders, scaffolding, safety lines and belts, and similar equipment used for demolition.

6.2 Contractor's employees, agents, contractors and subcontractors shall use personal protective equipment, safety harnesses, fall protection equipment, hard hats or other equipment required to perform the work in safe manner. Contractor will hold safety training, safety briefings or other meetings to ensure all staff are fully prepared to perform the work with safety in mind.

6.3 Contractor shall conduct daily safety and health inspections of the work site. Contractor shall promptly report any accidents, injuries, spills, or near misses to HFC.

7.0 Contractor Diversity Commitment

7.1 Contractor shall make good faith efforts to award subcontracts equal to **33%** of the value of this Agreement to certified, diverse suppliers of goods and services in accordance with the Contractor Diversity Program established by HFC, which is incorporated herein by this reference. Contractor shall disclose to HFC the manner and extent to which it has made good faith efforts to achieve such goal and submit reports on forms provided by HFC.

§8. Warranties. Contractor warrants that it shall perform all work in a good and workmanlike manner, meeting the standards of quality prevailing in Harris County, Texas for work of this kind. Contractor shall perform all work using trained and skilled persons having substantial experience performing the work required under this Contract as more fully described herein.

With respect to any parts and goods it furnishes, Contractor warrants: (a) that all items are free of defects in title, design, material, and workmanship, (b) that each item meets or exceeds the manufacturer's specifications and requirements for the equipment, structure, or other improvement in which the item is installed, (c) that each replacement item is new, in accordance with original equipment manufacturer's specifications, and of a quality at least as good as the quality of the item which it replaces (when the replaced item was new), and will not cause any manufacturer's warranties to lapse or become invalid, and (d) that no item or its use infringes any patent, copyright, or proprietary right.

Contractor warrants that original works of authorship developed by Contractor pursuant to the subject of this Contract, including their use by HFC in unaltered form, shall not infringe on any third party copyrights, patents or trade secrets. Contractor shall transfer to HFC any manufacturer's warranties which it has for materials used in connection with this Contract. Contractor is duly formed, validly existing and in good standing under the laws of the State of Texas.

8.0 Prevailing Wage Requirement

8.1 Contractor shall comply with governing statutes providing for labor classification of wage scales for each craft or type of laborer, worker, or mechanic.

8.2 Prevailing wage rates applicable to the work may be one or a combination of the following wage rates identified at **www.houstonfirst.com/DoBusiness.aspx**, which is incorporated herein for all purposes by this reference.

8.3 Contractor warrants and represents that it has carefully examined the classifications for each craft or type of worker needed to execute the work and determined that such classifications include all necessary categories to perform the work.

If Contractor believes that an additional classification for a particular craft or type of worker is necessary to perform work under the Contract, it must submit such request to HFC to use an additional labor classification not listed therein and specify the proposed new classification. If HFC decides that a new classification is necessary, it will determine the appropriate prevailing wage rate for any resurveyed, amended, new, or additional craft or type of worker not covered. Such determination will be made by HFC in compliance with applicable law.

8.4 Each week, Contractor shall submit directly to the HFC Project Manager certified copies of payrolls showing classifications and wages paid by Contractor, subcontractors, and suppliers for each employee under the Contract, for any day included in the Contract.

9.0 Payment and Performance Bonds Required

9.1 Contractor shall furnish payment and performance bonds equal to 100% of the contract on forms approved by HFC.

10.0. Insurance

10.1 Contractor shall provide and maintain in full force and effect from the date of execution of the agreement until final completion of the Work, including all extensions and amendments thereto, at least the following insurance and available limits of liability:

Commercial General Liability, including Contractor's Protective, Broad Form Property Damage, Contractual Liability, Explosion, Underground and Collapse, Bodily Injury, Personal Injury, Products and Completed Operations	Combined single limit of $1,000,000 per occurrence, subject to a general aggregate of $2,000,000; Products and Completed Operations $1,000,000 aggregate
Automobile Liability Insurance	$1,000,000 combined single limit including Owned, Hired, and Non-Owned and Auto Coverage
Workers' Compensation	Statutory for Workers' Compensation. Contractor is not allowed to self-insure Workers' Compensation
Employer's Liability	Bodily Injury by accident $1,000,000 (each accident) Bodily Injury by Disease $1,000,000 (policy limit) Bodily Injury by Disease $1,000,000 (each employee)
Owner's and Contractor's Protective Liability	$1,000,000 combined single limit
Excess Coverage	$1,000,000 each Occurrence/combined aggregate in excess of limits specified for Employer's Liability, Commercial General Liability, and Automobile Liability

10.2 Insurance may be in one or more policies of insurance, form of which is subject to approval by HFC. It is agreed, however, that nothing HFC does or fails to do with regard to insurance policies relieves Contractor from its duties to provide required coverage and HFC's actions or inactions will never be construed as waiving HFC's rights.

10.3 The issuer of any policy (1) shall have a Certificate of Authority to transact insurance business in Texas or (2) shall be an eligible non-admitted insurer in the State of Texas and have an A.M. Best rating of at least A– with a financial size category of Class VI or better.

10.4 Each policy, except those for Workers' Compensation and Owner's and Contractor's Protective Liability, must include an endorsement naming HFC and the City of Houston as additional insureds.

10.5 Waiver of Subrogation. Each policy except Owner's and Contractor's Protective Liability must contain endorsement to the effect that issuer waives any claim or right in nature of subrogation to recover against HFC and the City of Houston.

10.6 Endorsement of Primary Insurance. Each policy, except Workers' Compensation policies, must contain an endorsement that the policy is primary insurance to any other insurance available to the additional insureds with respect to claims arising hereunder.

10.7 Liability for Premium. Contractor is solely responsible for payment of all insurance premium requirements.

10.8 Subcontractor Insurance Requirements. Contractor shall require Subcontractors with whom it contracts directly, whose subcontracts exceed $50,000, to provide proof of Commercial General Liability, Workers' Compensation, and Employer's Liability coverage that meets all the requirements of section; provided, however, that the amount must be commensurate with the amount of the subcontract, but not less than $1,000,000 per occurrence.

11.0 Limitation of Liability

11.1 To the extent permitted by law, in no event shall HFC be liable to Contractor for any lost revenues, lost profits, incidental, indirect, consequential, special, or punitive damages. HFC's liability to Contractor shall under no circumstances exceed the total amount of fees actually paid by HFC to Contractor in connection with the contract between the parties.

12.0 Release

12.1 CONTRACTOR AGREES TO AND SHALL RELEASE HOUSTON FIRST CORPORATION, THE CITY OF HOUSTON, AND THEIR AGENTS, EMPLOYEES, OFFICERS, AND LEGAL REPRESENTATIVES (COLLECTIVELY, "INDEMNITEES") FROM ALL LIABILITY FOR INJURY, DEATH, DAMAGE, OR LOSS TO PERSONS OR PROPERTY SUSTAINED IN CONNECTION WITH OR INCIDENTAL TO PERFORMANCE UNDER THIS CONTRACT, EVEN IF THE INJURY, DEATH, DAMAGE, OR LOSS IS CAUSED BY THE INDEMNITEES' CONCURRENT NEGLIGENCE AND/OR THE INDEMNITEES' STRICT PRODUCTS LIABILITY OR STRICT STATUTORY LIABILITY AS WELL AS FROM ALL LIABILITY FOR DAMAGES OR OTHER RELIEF ARISING UNDER FEDERAL OR STATE EMPLOYMENT LAWS RELATING TO OR INVOLVING PERSONNEL EMPLOYED BY CONTRACTOR UNDER THE CONTRACT.

13.0 Indemnification

13.1 CONTRACTOR AGREES TO AND SHALL DEFEND, INDEMNIFY, AND HOLD HOUSTON FIRST CORPORATION, THE CITY OF HOUSTON, AND THEIR AGENTS, EMPLOYEES, OFFICERS, AND LEGAL REPRESENTATIVES (COLLECTIVELY, "INDEMNITEES") HARMLESS FOR ALL CLAIMS, CAUSES OF ACTION, LIABILITIES, FINES, AND EXPENSES (INCLUDING, WITHOUT LIMITATION, COPYRIGHT INFRINGEMENT, ATTORNEY'S FEES, COURT COSTS, AND ALL OTHER DEFENSE COSTS AND INTEREST) FOR INJURY, DEATH, DAMAGE, OR LOSS TO PERSONS OR PROPERTY SUSTAINED IN CONNECTION WITH OR INCIDENTAL TO PERFORMANCE UNDER THE CONTRACT AS WELL AS FOR ALL LIABILITY FOR DAMAGES OR OTHER RELIEF ARISING UNDER FEDERAL OR STATE EMPLOYMENT LAWS RELATING TO OR INVOLVING PERSONNEL EMPLOYED BY CONTRACTOR UNDER THE CONTRACT INCLUDING, WITHOUT LIMITATION, THOSE CAUSED BY OR RELATING TO: (I) CONTRACTOR AND/OR ITS AGENTS', EMPLOYEES', OFFICERS', DIRECTORS', CONTRACTORS', OR SUBCONTRACTORS' (COLLECTIVELY, "CONTRACTOR") ACTUAL OR ALLEGED NEGLIGENCE OR INTENTIONAL ACTS OR OMISSIONS; THE INDEMNITEES' AND CONTRACTOR'S ACTUAL OR ALLEGED CONCURRENT NEGLIGENCE, WHETHER CONTRACTOR IS IMMUNE FROM LIABILITY OR NOT; AND INDEMNITEES' AND CONTRACTOR'S ACTUAL OR ALLEGED STRICT PRODUCTS LIABILITY OR STRICT STATUTORY LIABILITY, WHETHER CONTRACTOR IS IMMUNE FROM LIABILITY OR NOT; AND (II) ACTUAL OR ALLEGED VIOLATIONS OF ANY FEDERAL OR STATE EMPLOYMENT LAWS, INCLUDING WITHOUT LIMITATION, ALL CLAIMS AND CAUSES OF ACTION BROUGHT AGAINST INDEMNITIES BY CONTRACTOR'S PERSONNEL AND/OR GOVERNMENT AGENCIES ARISING FROM, RELATING TO, OR INVOLVING SERVICES OF CONTRACTOR'S PERSONNEL UNDER THE CONTRACT.

13.2 CONTRACTOR SHALL DEFEND, INDEMNIFY, AND HOLD THE INDEMNITEES HARMLESS DURING THE TERM OF THIS CONTRACT AND FOR FOUR YEARS AFTER THE CONTRACT TERMINATES. CONTRACTOR SHALL NOT INDEMNIFY THE INDEMNITEES FOR THEIR SOLE NEGLIGENCE. CONTRACTOR SHALL REQUIRE ALL OF ITS CONTRACTORS AND SUBCONTRACTORS TO RELEASE AND INDEMNIFY THE INDEMNITEES TO THE SAME EXTENT AND IN SUBSTANTIALLY THE SAME FORM AS ITS RELEASE AND INDEMNITY TO THE INDEMNITEES.

14.0 Indemnification Procedures

14.1 If HFC or Contractor receives notice of any claim or circumstances, which could give rise to an indemnified loss, the receiving party shall give written notice to the other party within 30 days. The notice must include the following (1) a description of the indemnification event in reasonable detail, (2) the basis on which indemnification may be due, and (3) the anticipated amount of the indemnified loss.

14.2 This notice does not stop or prevent HFC from later asserting a different basis for indemnification or a different amount of indemnified loss than that indicated in the initial notice. If HFC does not provide this notice within the 30 day period, it does not waive any right to indemnification except to the extent that Contractor is prejudiced, suffers loss, or incurs expense because of the delay.

14.3 Contractor may assume the defense of the claim at its own expense with counsel chosen by it that is reasonably satisfactory to HFC. Contractor shall then control the defense and any negotiations to settle the claim. Within ten days after receiving written notice of the indemnification request, Contractor must advise HFC as to whether or not it will defend

the claim. If Contractor does not assume the defense, HFC may assume and control the defense, and all defense expenses constitute an indemnification loss.

14.4 If Contractor elects to defend the claim, HFC may retain separate counsel to participate in (but not control) the defense and to participate in (but not control) any settlement negotiations. Contractor may settle the claim without the consent or agreement of HFC, unless it (i) would result in injunctive relief or other equitable remedies or otherwise require the Indemnitees to comply with restrictions or limitations that adversely affect the Indemnitees, (ii) would require the Indemnitees to pay amounts that Contractor does not fund in full, (iii) would not result in the Indemnitees' full and complete release from all liability to the plaintiffs or claimants who are parties to or otherwise bound by the settlement.

15.0 Ownership of Intellectual Property

15.1 In the event that the work and material which is the subject of this contract is copyrightable subject matter, HFC and Contractor hereby agree that for the purpose of this Contract the work and material shall be a work-made-for-hire and the property of HFC. In the event that the work and material which is the subject of this contract is not copyrightable subject matter, or for any reason is determined not to be a work-made-for-hire, then Contractor hereby grants all right, title and interest to said work and material to HFC, and Contractor will promptly execute and deliver such documents as may be requested by HFC, in order to accomplish the transfer of all such right, title and interest.

16.0 Termination for Convenience

16.1 HFC may terminate the Contract at any time by giving 30 days' written notice to Contractor. HFC's right to terminate the Contract for convenience is cumulative of all rights and remedies, which exist now or in the future. On receiving such notice, Contractor shall, unless the notice directs otherwise, immediately discontinue all services under the Contract and cancel all existing orders and subcontracts that are chargeable to the Contract. As soon as practicable after receiving the termination notice, Contractor shall submit an invoice showing in detail the services performed under the Contract up to the termination date. HFC shall then pay the fees to Contractor for services actually performed, but not already paid for.

17.0 Termination for Cause

17.1 If Contractor defaults under the Contract, HFC may either terminate the Contract or allow Contractor to cure the default as provided below. HFC's right to terminate the Contract for Contractor's default is cumulative of all rights and remedies, which exist now or in the future. Default by Contractor occurs if: (a) Contractor fails to perform any of its duties under the Contract, (b) Contractor becomes insolvent, (c) all or a substantial part of Contractor's assets are assigned for the benefit of its creditors, or (d) a receiver or trustee is appointed for Contractor.

17.2 If a default occurs, HFC may, but is not obligated to, deliver a written notice to Contractor describing the default and the termination date. HFC, in its sole discretion, may extend the termination date to a later date. If HFC allows Contractor to cure the default and Contractor does so to the satisfaction of HFC before the termination date, then the termination is ineffective. If Contractor does not cure the default before the termination date, then HFC may terminate the contract on the termination date, at no further obligation of HFC.

17.3 To effect final termination, HFC must notify Contractor in writing. After receiving the notice, Contractor shall, unless the notice directs otherwise, immediately discontinue all services under the Contract, and promptly cancel all orders or subcontracts chargeable to the Contract.

18.0 Governing Law/Venue

18.1 The Contract shall be governed by the laws of the State of Texas, without regard to any conflict of law provisions. Litigation in connection with this Contract shall be in a court of competent jurisdiction in Harris County, Texas.

SECTION 23 09 23 DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 GENERAL

1.1 SUMMARY

A. Section includes control equipment and software.

B. Related Sections:

1. Section 23 09 93 - Sequence of Operations for HVAC Controls: Sequences of operation implemented using products specified in this section.

2. Division 26 -Execution requirements for electric connections specified by this section.

1.2 SCOPE OF WORK – OVERVIEW

A. Systems to be controlled and/or monitored by the new BAS system are:

a. Ambient outside air conditions

b. Space temperatures and humidities

c. HVAC equipment: chiller, pumps, cooling towers, boiler, fans, air handlers, fan coils, space heaters

d. Plumbing Equipment: domestic water boilers, domestic water pumps, sewage ejectors, sump pumps

e. Electrical Equipment: generator alarm panel

f. Existing Lighting contactors

g. Fire alarm- alarm status only

2. There is no control, monitoring or interface of these systems:

a. Security

B. The purposes of this project are:

1. Convert to 100%. DDC controls and monitoring. There shall be no remaining pneumatic sensors, controllers, operators, EP switches or devices.
2. Provide a system that is fully non-proprietary and having a web-based interface
3. Provide current versions of systems and operator interface software
4. Implement new Sequences of Operation
5. Add VFDs to certain equipment
6. Add control/ monitoring of certain fans that are not currently on the BAS
7. Provide an Operator Interface User interface consistent with BAS systems installed at the George R. Brown Convention Center. The intent is that operators and maintenance personnel could move from one building to another and not have to learn a new system. Operators should see similar screens, reports and action buttons at each building.

C. There are Bid Alternates – see section below

1.3 BID ALTERNATE #1 SCOPE – UPGRADE OF 3 CHILLERS CONTROL PANELS

1. Existing Chillers 1,2 &3 are York YT –J1-K-E3-CU-1; SERIAL 038268 or similar
2. Chiller can currently be commanded on/ off by the BAS but chiller diagnostics and performance metrics are not available to the BAS.

3. Bid Alternate is to replace all 3 chiller control panels with York/JCI panels such that BAS can monitor, trend and log all data available as standard or York/ JCI such as alarms, faults, refrigerant pressures & temperatures, current by phase, operating hours.

4. See section 3.1 2 of this specification.

1.4 BID ALTERNATE #2 SCOPE : CENTRAL PLANT OPTIMIZATION

A. Required as a Bid Alternate. See description in 23 09 93 Sequences of Operation

1.5 VOLUNTARY BID ALTERNATES

A. Voluntary bid alternates may be proposed by the contractor. Bid alternates shall state all deviations from project specs and the associated bid increase or decrease.

1.6 REFERENCES

A. American National Standards Institute:

1. ANSI MC85.1 - Terminology for Automatic Control.

1.7 EXISTING SYSTEMS ARCHITECTURE

A. Johnson Metasys :
1. The existing system is Johnson Metasys (version 12.041)
2. This system serves all equipment not listed in section B below
3. The system version is Johnson's 'PMI' series. PMI series components are no longer directly supported by Johnson Controls.
4. The system communicates via N2 protocol
5. Sensors report to N2 Field Equipment Controllers. The field controller issues commands to damper, valves and other devices.
6. Field Equipment Controllers report (in N2 protocol) to and are monitored by network control modules ('NCMs' in Johnson parlance).
7. The existing NCMs report (using N2) to the user interface
8. Space sensors, Valve and damper operators: currently generally pneumatic

B. Johnson Facility Explorer FX 60
1. Johnson Facility Explorer FX 60 (Tridium Niagara based, version 3.3 is installed).
2. Equipment served is:
   a. Chiller #4 and its pumps and pump VFDs
   b. AHUs 2-1, 4-1A, 4-1B, 5-2, 6-2, 7-14, 7-15
3. Existing field controllers are DDC. These controllers can communicate using N2, LON or BACnet protocol; currently they are configured to use N2
4. FX components have been integrated with the Metasys system for a single user workstation interface
5. Space sensors, valve and damper operators: generally direct digital

C. Common User Interface

1. A dedicated computer and monitors in the building engineer's office provide an integrated user access to both the Metasys and FX systems

2. Access via the internet is not currently configured

1.8 NEW BAS SYSTEM DESCRIPTION- GENERAL

A. Web based, allowing full access and control from the Internet. Full access includes adjusting time schedules, optimum start stop variables, energy management, demand control and trend logging.

B. Automatic temperature controls, field monitoring and control system using field programmable microprocessor based units

C. Distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire or fiber and conduit.

D. Wired or wireless devices, at Contractor's option

E. Provide computer software and hardware, operator input/output devices, control units, local area networks (LAN), sensors, control devices, actuators.

F. Provide control systems consisting of temperature sensors, control valves, dampers and operators, indicating devices, interface equipment and other apparatus and accessories to operate mechanical systems, and to perform functions specified.

G. Provide installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.

H. LON or BACnet based; non-proprietary architecture for all devices and systems

1.9 NEW BAS SYSTEM DESCRIPTION: **RE-USE OF EXISTING COMPONENTS**

A. Existing DDC **sensors** (space temperature, water or air temperature, static pressure sensors, differential pressures, freezestat, etc.) may remain as long as they are fully compatible with new BAS systems

B. Existing DDC sensor-to-controller **cabling** may remain as long as it is fully functional and compatible with new BAS systems

C. Existing automatic modulating dampers may remain. Pneumatic damper operators shall be replaced with DDC operators. DDC **damper operators** may remain as long as they are fully compatible with new BAS systems and communicate directly in BACnet without use of an interpreter. Operators communicating only in N2 must be replaced

D. **Chilled water valves**: Existing automatic modulating or open/close water valves may remain. Pneumatic operators shall be replaced with DDC operators. DDC **valve operators** may remain as long as they are fully compatible with new BAS systems and communicate directly in BACnet without use of an interpreter. Operators communicating only in N2 must be replaced.

E. **Heating hot water valves**: Existing automatic modulating water valves shall be replaced. Pneumatic operators shall be replaced with DDC operators. DDC **valve operators** may remain as long as they are fully compatible with new BAS systems and communicate directly in BACnet without use of an interpreter. Operators communicating only in N2 must be replaced.

F. Existing DDC **Field Equipment Controllers/ Application Controllers** (air handler controllers, pumps controllers, etc.) may remain as long as they are fully compatible with new BAS systems and communicate directly in BACnet without use of an interpreter. Devices communicating only in N2 must be replaced

G. **Chiller control panels:**

1. Chillers 1,2& 3 : existing control panels remain in Base Bid; see Bid Alternate description in section 1.3

2. Chiller 4: existing control panels remains but shall be adapted to communicate in BACnet

H. Existing network **cabling:** see section 2.6

I. Existing DDC **Network Control Modules** may remain as long as they are fully compatible with new BAS systems and communicate directly in BACnet without use of an interpreter. Devices communicating only in N2 must be replaced

J. Existing systems **Servers** and **Operator Interface** computer & monitors shall be replaced.

1.10 SUBMITTALS

A. SCOPE CONFIRMATION PRIOR TO SHOP DRAWINGS SUBMITTAL

1. Successful bidder shall, **prior to shop drawing submittal**, confirm all existing points and advise Engineer of any differences between actual points and those listed in this bid package.

B. SEQUENCE OF OPERATIONS CONFIRMATION, PRIOR TO SHOP DRAWINGS SUBMITTAL

1. Successful bidder shall, prior to shop drawing submittal, document and submit to Engineer the logic, setpoints and parameters of all existing control algorithms.

C. Shop Drawings: Indicate the following:

1. System graphics showing monitored systems, data (connected and calculated) point addresses, and operator notations.

2. System configuration with peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.

3. Description and sequence of operation for operating, user, and application software.

D. Product Data: Submit data for each system component and software module.

E. Manufacturer's Installation Instructions: Submit installation instruction for each control system component.

1.11 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors.

1. Provide AutoCAD or Revit 2014 or higher shop drawings to reflect actual installation (Owner will provide AutoCad backgrounds at no cost)

2. Submit hard copy documentation of final sequence of operations, clearly showing algorithms and logic trees used

3. Submit data specified in "Submittals" in final "Record Documents" form.

B. Operation and Maintenance Data (provide both hard copy, plus electronic versions of each):

1. Submit interconnection wiring diagrams complete field installed systems with identified and numbered system components and devices.

2. Submit keyboard illustrations and step-by-step procedures indexed for each operator function.

3. Submit inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

4. Embed or hyperlink electronic versions to provide electronic accessing a via the operator BAS interface

1.12 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three year's experience, and with service facilities within 50 miles of Project. The company shall have completed a minimum of five (5) projects of similar scope and size within the last three (3) years.

B. Installer: Company specializing in performing work of this section with minimum three years experience.

C. Project Manager. The controls contractor shall assign a qualified project manager to this project. The project manager shall not be required to work full time on this project. However, he/she shall attend all coordination meetings with the Owner, shall oversee the progress schedule, shall coordinate the work of the installation team, shall be an expert on the hardware and software being installed. A resume of the Project Manager shall be submitted with the bid/proposal.

1.13 PRE-INSTALLATION MEETINGS

A. Convene prior to commencing work of this section.

1.14 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.15 WARRANTY

A. 1 year all parts and labor, from date of Owners written acceptance.

B. Provide product warranties.

1.16 WARRANTY & MAINTENANCE SERVICE

A. Furnish service and maintenance of control systems during warranty period

B. During warranty period furnish a minimum of 4 **quarterly inspections per year**, to inspect, calibrate, and adjust controls. Submit written report after each inspection.

C. Repair or replace parts in accordance with manufacturer's operating and maintenance data. Use parts produced by manufacturer of original equipment.

D. Perform work without removing units from service during building normal occupied or event hours.

E. Provide emergency call back service at all hours for the warranty period. Emergencies shall include loss of HVAC services prior to or during scheduled events

1. Respond to emergency calls within 2 hours via telephone or internet

2. Have technician on site within 4 hours

F. Maintain in Houston area, adequate stock of parts for replacement or emergency purposes. Have personnel available to ensure fulfillment of this maintenance service, without unreasonable loss of time.

G. Perform warranty work using competent and qualified personnel.

H. Do not assign or transfer *maintenance service* to agent or subcontractor without prior written consent of Owner.

I. Provide, at no additional cost, all software upgrades issued by vendor during the warranty period.

J. If requested (at extra cost, with prior written authorization) have technicians onsite during scheduled events.

K. For the purpose of warranty servicing: include remote monitoring and trouble shooting of the system via the internet during warranty period.

1.17 ACCESS TO THE SITE/ INTERRUPTION OF BUILDING SERVICES

A. Access to the site, allowable work hours and interruption of building services must be scheduled in advance with owner and is subject to their event schedule (which is not fully known at the time of bid). See General Conditions, Bidder instructions and Division 1 of the specifications. Attend the pre bid meeting to receive further information.

PART 2 PRODUCTS

2.1 DIRECT DIGITAL CONTROLS

A. PRE-APPROVED VENDORS and/or INSTALLERS
1. Computrols
2. Convergentz
3. Delta Controls

4. Digital Air Controls
5. Johnson Controls, Inc.
6. Open Tech
7. Siemens
8. Tekplan
9. TD Industries
10. UES

B. Other Vendors

1. Request approval in writing prior to bid date.
2. Do not submit bid without written authorization from Owner. Verbal approvals or approvals from Engineer, Owner or others are not acceptable.

2.2 OPERATOR WORKSTATION

A. Access shall be from any PC which is connected to the web based control system via a webrowser. No additional hardware of software shall be required.

B. Owner will stipulate PCs in the bldg that require access to the BAS. Each location shall be checked by the BAS vendor and any adjustments made to allow access and that person shown how to access and navigate the system.

C. One **new** desk-mounted operator workstation, monitor and laser printer is required and shall replace the existing work station/ monitor/ printer in the building engineer's office.

D. Sufficient memory for a minimum of one month's data on the operator

E. Surge arrestor.

2.3 PORTABLE OPERATOR'S TERMINAL

A. Provide two portable terminals (such as iPad, current version) capable of accessing system data directly from BAS controllers and capable of being connected to any point on system network or connected directly to any controller for programming, set-up, and troubleshooting. Tablets shall be functional anywhere that wireless access is available in the entire complex. Tablets shall have built in G3 capability, but it is Owner's responsibility to activate and pay for G3 network access if desired.

2.4 WEB SERVER

A. The new WEB Server Hardware shall comply with the following:

1. Operating System: Microsoft Windows Server or Microsoft Windows Server (current editions) allowing multiple simultaneous user access

B. The Web Server Hardware shall retain and backup of the databases within each control unit

C. The WEB Enabled Application software and Graphical User Interface (GUI) is to be stored on the WEB hard disk drive server.

D. The WEB Server Software shall be web based or comply with the following:

1. Provide licensed copy of the Control System WEB Enabled Application Software. This license shall allow unlimited isolated systems to be served. Subject to Owner's legal review, the Owner shall execute a copy of the manufacturer's standard software and firmware licensing agreement. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.

2. Web server shall be located in building engineer's office and replaces the existing computer in that location. If allowed by BAS vendor, this same server will also be used by building engineer to access the LAN and for non-BAS functions (word processing, email etc). Copy engineer's existing files, settings and program to new server.

E. UPS/Surge arrestor.

2.5 CONTROL UNITS (Field Equipment Controllers/ Application Controllers)

A. Units: Modular in design and consisting of processor board with programmable RAM memory, local operator access and display panel, and integral interface equipment.

B. Battery Backup: For minimum of 48 hours for complete system including RAM without interruption, with automatic battery charger.

C. Control Units Functions:

1. Monitor or control each input/output point.
2. Completely independent with hardware and software to maintain control independently.
3. Acquire, process, and transfer information to operator stations or other control units on network.
4. Accept, process, and execute commands from other control unit's or devices or operator stations.
5. Access both data base and control functions simultaneously.
6. Record, evaluate, and report changes of state or value occurring among associated points. Continue to perform associated control functions regardless of status of network.
7. Perform in stand-alone mode, all required by Sequences of Operation, plus:
   a. Start/stop.
   b. Event initiated control.
   c. Calculated point.
   d. Scanning and alarm processing.
   e. Full direct digital control.
   f. Trend logging.
   g. Global communications.
   h. Maintenance scheduling.

D. Global Communications:
1. Broadcast point data onto network, making information available to other system controls units.
2. Transmit input/output points onto network for use by other control units and use data from other control units.

E. Input/output Capability:
1. Discrete/digital input (contact status).
2. Discrete/digital output.
3. Analog input.
4. Analog output.
5. Pulse input.
6. Pulse output (0-655 seconds in duration with 0.01-second resolution).

F. Monitor, control, or address data points. Include analog inputs, analog outputs, pulse inputs, pulse outputs and discrete inputs/outputs. Furnish control units with minimum 15 percent spare capacity.

G. Point Scanning: Set scan or execution speed of each point to network

H. Upload/Download Capability: Download from or upload to network.

I. Test Mode Operation: Place input/output points in test mode to allow testing and developing of control algorithms on line without disrupting field hardware and controlled environment.

2.6 LOCAL AREA NETWORKS (LAN):

A. Furnish communication between control units and a controls-dedicated local area network (LAN).

B. Owner’s internal LAN cabling for non-controls functions CANNOT BE USED BY CONTROLS VENDOR

C. EXISTING BAS CABLING/FIBER MAY BE RE-USED IF IT IS DEDICATED EXCLUSIVELY TO THE BAS, HAS BEEN TESTED BY THIS BAS CONTRACTOR, MEETS THE TECHNICAL AND INSTALLATION REQUIREMENTS OF THIS SPEC AND IS FULLY WARRANTED BY THIS CONTRACTOR.

D. Break in Communication Path: generate an alarm and, if possible, automatically re-route signals around the break.

E. LAN Data Speed: Minimum 19.2 Kb.

F. Transmission Media: Fiber optic or single pair of solid 24 gauge twisted, shielded copper cable.

G. Network Support: Maximum time for global point to be received by any station, less than 3 seconds. Furnish automatic reconfiguration when station is added or lost. In event transmission cable is cut, reconfigure two sections with no disruption to system's operation, without operator intervention.

2.7 OPERATING SYSTEM SOFTWARE

A. Input/output Capability From Operator Stations (with appropriate access permission):
1. Request display of current values or status in tabular or graphic format.
2. Command selected equipment to specified state.
3. Initiate logs and reports.
4. Change analog limits.
5. Add, delete, or change points within each control unit or application routine.
6. Change point input/output descriptors, status, alarm descriptors, and unit descriptors.
7. Add new control units to system.
8. Modify and set up maintenance scheduling parameters.
9. Develop, modify, delete or display full range of color graphic displays.
10. Automatically archive select data even when running third party software.
11. Capability to sort and extract data from archived files and to generate custom reports.
12. Support multiple printer operations.
13. Alarm printer: Print alarms, operator acknowledgments, action messages, system alarms, operator sign-on and sign-off.
14. Data printer: Print reports, page prints, and data base prints.
15. Select daily, weekly or monthly as scheduled frequency to synchronize time and date in digital control units. Accommodate daylight savings time adjustments.
16. Print selected control unit database.

B. Operator System Access: Via software password with minimum 3 access levels

C. Data Base Creation and Support: Use standard procedures for changes. Control unit automatically checks workstation data base files upon connection and verify data base match. Include the following minimum capabilities:

1. Add and delete points.
2. Modify point parameters.
3. Change, add, or delete English language descriptors.
4. Add, modify, or delete alarm limits.
5. Add, modify, or delete points in start/stop programs, trend logs, and other items.
6. Create custom relationship between points.
7. Create or modify DDC loops and parameters.
8. Create or modify override parameters.
9. Add, modify, and delete applications programs.
10. Add, delete, develop, or modify dynamic color graphic displays.

D. Dynamic Color Graphic Displays:
1. Utilizes custom symbols or system supported library of symbols.
2. Minimum Sixteen (16) colors.
3. Dynamic graphic data.
4. Modify graphic screen refresh rate between 1 and 60 seconds.

E. Operator Stations:
1. Accept data from LAN as needed without scanning entire network for updated point data.
2. Interrogate LAN for updated point data when requested.
3. Allow operator command of devices.
4. Allow operator to place specific control units in or out of service.
5. Allow parameter editing of control units.
6. Store duplicate data base for every control unit and allow down loading while system is on line.

7. Control or modify specific programs.
8. Develop, store and modify dynamic color graphics.
9. Data archiving of assigned points and support overlay graphing of this data

F. Alarm Processing:

1. Off normal condition: Cause alarm and appropriate message, including time, system, point descriptor, and alarm condition. Select alarm state or value and alarms causing automatic dial-out.
2. Critical alarm or change-of-state: Display message, stored on disk for review and sort, or print.
3. Print on line changeable message, up to 60 characters in length, for each alarm point specified.
4. Display alarm reports on video. Display multiple alarms in order of occurrence.
5. Define time delay for equipment start-up or shutdown.
6. Allow unique routing of specific alarms.
7. Operator specifies when alarm requires acknowledgment.
8. Continue to indicate unacknowledged alarms after return to normal.
9. Alarm notification:
10. Print automatically.
11. Display indicating alarm condition.
12. Selectable audible alarm indication.

G. Event Processing: Automatically initiate commands, user defined messages, take specific control actions or change control strategy and application programs resulting from event condition. Event condition may be value crossing operator defined limit, change of state, specified state, or alarm occurrence or return to normal.

H. Automatic Restart: Automatically start field equipment on restoration of power. Furnish time delay between individual equipment restart and time of day start/stop.

I. Messages:
1. Automatically display or print user-defined message subsequent to occurrence of selected events.
2. Compose, change, or delete message.
3. Display or log message at any time.
4. Assign any message to event.

J. Reports:
1. Manually requested with time and date.
2. Long term data archiving to hard disk.
3. Automatic directives to download to transportable media for storage.
4. Data selection methods to include data base search and manipulation.
5. Data extraction with mathematical manipulation.
6. Data reports to allow development of XY curve plotting, tabular reports (both statistical and summary), and multi-point timed based plots with not less than four (4) variables displayed.
7. Generating reports either normally at operator direction, or automatically under workstation direction.
8. Either manually display or print reports. Automatically print reports on daily, weekly, monthly, yearly or scheduled basis.
9. Include capability for statistical data manipulation and extraction.
10. Capability to generate four types of reports: Statistical detail reports, summary reports, trend graphic plots, x-y graphic plots.

K. Parameter Save/Restore: Store most current operating system, parameter changes, and modifications on disk or diskette.

L. Data Collection:

1. Automatically collect and store in disk files.
2. Archiving of stored data for use with system supplied custom reports.

M. Graphic Display: Support graphic development on work station with software features:
1. Provide real-time graphics of all points and systems; graphics shall include indication of data in alarm or outside or normal parameters.
2. Animated graphics for discrete points.
3. Analog bar graphs.

4. Screens shall include:

   a. Building plans of all floors with location of all controlled equipment, boxes, dampers, valves, sensors.
      1) Clicking on equipment takes you to that equipment screen

   b. Schematics of each equipment type (air handler, fan, chiller, pump, tower boiler, etc.) with realtime data and ability to reset schedules, setpoints and alarm parameters

   c. Central plant diagrams showing chilled water, condenser water and hot water process diagrams with realtime data and ability to reset schedules, setpoints and alarm parameters

   d. Alarm view showing or listing devices in alarm and alarm status (active, acknowledged, cleared)

   e. List view of equipment or spaces with realtime data and ability to reset schedules, setpoints and alarm parameters

5. PROVIDE AN OPERATOR INTERFACE USER INTERFACE CONSISTENT WITH BAS SYSTEM INSTALLED AT THE GEORGE R. BROWN CONVENTION CENTER. THE INTENT IS THAT OPERATORS AND MAINTENANCE PERSONNEL COULD MOVE FROM ONE BUILDING TO ANOTHER AND NOT HAVE TO LEARN A NEW SYSTEM. OPERATORS SHOULD SEE SIMILAR SCREENS, REPORTS AND ACTION BUTTONS AT EACH BUILDING.

N. Maintenance Management:

1. Run time monitoring and logging, for each point.
2. Accumulated starts, for each piece of equipment (air handler, fan).
3. Maintenance scheduling targets with automatic annunciation, scheduling and shutdown.
4. Equipment safety targets.
5. Target point reset, for each point.

O. Advisories:

1. Summary containing status of points in locked out condition.
2. Continuous operational or not operational report of interrogation of system hardware and programmable control units for failure.
3. Report of power failure detection, time and date.
4. Report of communication failure with operator device, field interface unit, point and programmable control unit.

2.8 LOAD CONTROL PROGRAMS

A. General: The systems, as installed and with no additional software, shall be capable of implementing any of the following programs. IMPLEMENT UNDER THIS CONTRACT ONLY THOSE CALLED FOR IN THE POINTS LIST AND/OR SEQUENCES OF OPERATION OF THIS PROJECT SPECIFICATION.

B. Demand Limiting:

1. Monitor total power consumption for each power meter and shed associated loads automatically to reduce power consumption to an operator set maximum demand level.
2. Input: Pulse count from incoming power meter connected to pulse accumulator in control unit.
3. Forecast demand (kW): Predicted by sliding window method.
4. Automatically shed loads throughout the demand interval selecting loads with independently adjustable on and off time of between one and 255 minutes.
5. Demand Target: Minimum of 3 for each demand meter; change targets based upon (1) time, (2) status of pre-selected points, or (3) temperature.
6. Load: Assign load shed priority, minimum "ON" time and maximum "OFF" time.
7. Limits: Include control band (upper and lower limits).
8. Output advisory when loads are not available to satisfy required shed quantity

C. Duty Cycling:

1. Periodically stop and start loads, based on space temperature, and according to various On/Off patterns.

2. Modify off portion of cycle based on operator specified comfort parameters. Maintain total cycle time by increasing on portion of cycle by equal quantity off portion is reduced.
3. Set and modify following parameters for each individual load.

    a. Minimum and maximum off time.
    b. On/Off time in one-minute increments.
    c. Time period from beginning of interval until cycling of load.
    d. Manually override the DDC program and place a load in an On or Off state.
    e. Cooling Target Temperature and Differential.
    f. Heating Target Temperature and Differential.
    g. Cycle off adjustment.

D. Automatic Time Scheduling:

1. Self-contained programs for automatic start/stop/scheduling of building loads.
2. Support up to seven (7) normal day schedules, seven (7) "special day" schedules and two (2) temporary day schedules.
3. Special days schedule supporting multiple unique date/duration combinations.
4. Number of loads assigned to time program; with each load having individual time program.
5. Each load assigned at least 16 control actions for each day with 1 minute resolution.
6. Furnish the following time schedule operations:

    a. Start.
    b. Optimized Start.
    c. Stop.
    d. Optimized Stop.
    e. Cycle.
    f. Optimized Cycle.
7. Capable of specifying holiday periods for the year.
8. Create temporary schedules.
9. Broadcast temporary "special day" date and duration.

E. Start/Stop Time Optimization:
1. Perform optimized start/stop as function of outside conditions, inside conditions, or both.
2. Adaptive and self-tuning, adjusting to changing conditions unattended.
3. For each point under control, establish and modify:
    a. Occupancy period.
    b. Desired temperature at beginning of occupancy period.
    c. Desired temperature at end of occupancy period.

F. Night Setback/Setup Program: Reduce heating space temperature set point or raise cooling space temperature set-point during unoccupied hours; in conjunction with scheduled start/stop and optimum start/stop programs.

G. Calculated Points: Define calculations and totals computed from monitored points (analog/digital points), constants, or other calculated points.
1. Employ arithmetic, algebraic, Boolean, and special function operations.
2. Treat calculated values like any other analog value; use for any function where a "hard wired point" might be used.

H. Event Initiated Programming: Any data point capable of initiating event, causing series of controls in a sequence.
1. Define time interval between each control action.
2. Output may be analog value.
3. Provide for "skip" logic.
4. Verify completion of one action before proceeding to next action. When not verified, program capable of skipping to next action.

I. Direct Digital Control: Furnish with each control unit Direct Digital Control software so operator is capable of customizing control strategies and sequences of operation by defining appropriate control loop algorithms and choosing optimum loop parameters.
1. Output: Paired or individual digital outputs for pulse width modulation, and analog outputs.
2. Firmware:
    a. PID with analog or pulse-width modulation output.

b. Floating control with pulse-width modulated outputs.
c. Two-position control.
d. Primary and secondary reset schedule selector.
e. Hi/Low signal selector.
f. Single pole double-throw relay.
g. Single pole double throw time delay relay with delay before break, delay before make and interval time capabilities.

3. Direct Digital Control loop: Downloaded upon creation or on operator request. On sensor failure, program executes user defined failsafe output.
4. Display: Value or state of each of lines interconnecting DDC modules.

J. Fine Tuning Direct Digital Control PID or floating loops:
1. Display information:
a. Control loop being tuned.
b. Input (process) variable.
c. Output (control) variable.
d. Set-point of loop.
e. Proportional band.
f. Integral (reset) Interval.
g. Derivative (rate) Interval.

K. Trend logging:
1. Trend logging shall be accomplished by operator without any special programming skills
2. Each control unit capable of storing samples of control unit's data points.
3. Update file continuously at operator assigned intervals.
4. Automatically initiate upload requests and then stores data on hard disk.
5. Time synchronize sampling at operator specified times and intervals with sample resolution of one minute.
6. Co-ordinate sampling with specified on/off point- state.
7. Display trend samples on workstation in graphic format.

L. Sub meter billing
1. Collect date from meters of tenant power and/or btuh consumption
2. Generate report of power or btuh consumption per meter for stipulate metering period
3. Maintain metering report for prior two years
4. Create graphs and/or excel spreadsheet of meter data, including comparisons to same period in prior years

M. Tenant requests for after hours HVAC and/or lights
1. BAS shall allow tenants, using a valid password, to request HVAC and lighting system activation for their space (and associated common areas) during normally unoccupied hours
2. Tenant must indicate a specific start and stop time
3. Generate report of who requested the activation; date and duration of each activation. Generate report for user-selected billing period
4. Maintain report data for a one year period

2.9 HVAC CONTROL PROGRAMS

A. General: The systems, as installed and with no additional software, shall be capable of implementing any of the following programs. Implement under this contract only those called for in the points list and/or sequence of operation of this project specification.

B. Optimal Run Time:
1. Control start-up and shutdown times of HVAC equipment.
2. Based on occupancy schedules, outside air temperature, seasonal requirements, and interior room temperature.
3. Start-up systems by using outside air temperature, room mass temperatures, and adaptive model prediction for how long building takes to warm up or cool down under different conditions.
4. Use outside air temperature to determine early shut down with ventilation override.
5. Analyze multiple sensors to determine seasonal mode and worse case condition for each day.
6. Operator commands:
a. Define term schedule.
b. Add/delete fan status point.
c. Add/delete outside air temperature point.

d. Add/delete temperature point.
e. Define heating/cooling parameters.
f. Define mass sensor heating/cooling parameters.
g. Lock/unlock program.
h. Request optimal run-time control summary.
i. Request optimal run-time mass temperature summary.
j. Request HVAC point summary.
k. Request HVAC saving profile summary.

7. Control Summary:
   a. HVAC Control system begin/end status.
   b. Optimal run time lock/unlock control status.
   c. Heating/cooling mode status.
   d. Optimal run time schedule.
   e. Start/Stop times.
   f. Selected mass temperature point ID.
   g. Optimal run-time system normal start-times.
   h. Occupancy and vacancy times.
   i. Optimal run time system heating/cooling mode parameters.

8. Mass temperature summary:
   a. Mass temperature point type and ID.
   b. Desired and current mass temperature values.
   c. Calculated warm-up/cool-down time for each mass temperature.
   d. Heating/cooling season limits.
   e. Break point temperature for cooling mode analysis.

9. HVAC point summary:
   a. Control system identifier and status.
   b. Point ID and status.
   c. Outside air temperature point ID and status.
   d. Mass temperature point ID and status.
   e. Calculated optimal start and stop times.
   f. Period start.

C. Supply Air Reset:

1. Monitor heating and cooling loads in building spaces, terminal reheat systems, both hot deck and cold deck temperatures on dual duct and multizone systems, single zone unit discharge temperatures.

2. Adjust discharge temperatures to most energy efficient levels satisfying measured load by:
   a. Raising cooling temperatures to highest possible value.
   b. Reducing heating temperatures to lowest possible level.

3. Operator commands:
   a. Add/delete fan status point.
   b. Lock/unlock program.
   c. Request HVAC point summary.
   d. Add/Delete discharge controller point.
   e. Define discharge controller parameters.
   f. Add/delete air flow rate.
   g. Define space load and load parameters.
   h. Request space load summary.

4. Control summary:
   a. HVAC control system status (begin/end).
   b. Supply air reset system status.
   c. Optimal run time system status.
   d. Heating and cooling loop.
   e. High/low limits.
   f. Deadband.

g. Response timer.
h. Reset times.
5. Space load summary:
a. HVAC system status.
b. Optimal run time status.
c. Heating/cooling loop status.
d. Space load point ID.
e. Current space load point value.
f. Control heat/cool limited.
g. Gain factor.
h. Calculated reset values.
i. Fan status point ID and status.
j. Control discharge temperature point ID and status.
k. Space load point ID and status.
l. Airflow rate point ID and status.

D. Enthalpy Switchover:

1. Calculate outside and return air enthalpy using measured temperature and relative humidity; determine energy expended and control outside and return air dampers.

2.10 CHILLER CONTROL PROGRAMS/ CENTRAL PLANT OPTIMIZATION

A. Required as a Bid Alternate. See description in 23 09 93 Sequences of Operation.

B. Successful bidder only: shall submit a detailed description of their central plant (chiller, towers, pumps) optimization package plus an estimate of energy costs saved for this particular project (a computer 8760 hour energy model using load profile and other info provided by the Owner) .

2.11 PROGRAMMING APPLICATION FEATURES

A. Trend Point:

1. Sample points, real or computed, with each point capable of collecting samples at intervals specified in minutes, hours, days, or month.

2. Output trend logs as line-graphs or bar graphs. Output graphic on terminal, with each point for line and bar graphs designated with a unique pattern or color, vertical scale either actual values or percent of range, and horizontal scale time base. Print trend logs up to 12 columns of one point/column.

B. Alarm Messages:

1. Allow definition of messages, each having minimum length of 30 characters for each individual message.

2. Assign alarm messages to system messages including point's alarm condition, point's off-normal condition, totaled point's warning limit, hardware elements advisories.

3. Output assigned alarm with "message requiring acknowledgment".

4. Operator commands include define, modify, or delete; output summary listing current alarms and assignments; output summary defining assigned points.

C. Weekly Scheduling:
1. Automatically initiate equipment or system commands, based on selected time schedule for points specified.
2. Program times for each day of week, for each point, with one minute resolution.
3. Automatically generate alarm output for points not responding to command.
4. Allow for holidays, minimum of 3 years of holidays.
5. Operator commands:
a. System logs and summaries.
b. Start of stop point.
c. Lock or unlock control or alarm input.

d. Add, delete, or modify analog limits and differentials.
e. Adjust point operation position.
f. Change point operational mode.
g. Open or close point.
h. Enable/disable, lock/unlock, or execute interlock sequence or computation profile.
i. Begin or end point totals.
j. Modify total values and limits.
k. Access or secure point.
l. Begin or end HVAC or load control system.
m. Modify load parameter.
n. Modify demand limiting and duty cycle targets.

6. Output summary: Listing of programmed function points, associated program times, and respective day of week programmed points by software groups or time of day.

D. Interlocking:
1. Permit events to occur, based on changing condition of one or more associated master points.
2. Binary contact, high/low limit of analog point or computed point capable of being used as master. Master capable of monitoring or commanding multiple slaves.
3. Operator commands:
a. Define single master/multiple master interlock process.
b. Define logic interlock process.
c. Lock/unlock program.
d. Enable/disable interlock process.
e. Execute terminate interlock process.
f. Request interlock type summary.

2.12 SOFTWARE UPGRADES
A. Include all software upgrades issued from one year from start of the warranty period , plus Owner training on the upgrades

2.13 SHARING OF ALGORITHMS AND LOGIC
A. All algorithms and logic used in sequences of operation shall be shared with Owner, shall be fully described in the submittals and shall be re-programmable by the Owner without special software or added cost.
1. Any exceptions taken, such as algorithms considered proprietary, shall be identified by the bidder at the time of bid.

2.14 FIELD HARDWARE/INSTRUMENTATION
A. Sensors
1. Temperature sensors shall have accuracy rating of within 1% of the temperature range of their intended use.
2. New or replacement space temperature sensors shall be recessed with faceplate flush with wall surface and have:
a. NO Local set point adjustment
b. NO Setpoint indication
c. NO thermometer or space temperature display.
d. NO timed local over-ride
e. Brushed aluminum cover.
f. Insulating Bases: For thermostats located on exterior walls
3. Chilled water and condenser water sensors shall have an accuracy of +0.36°F in their range of application.
4. Hot water temperature sensors shall have an accuracy of +0.75°F over the range of their application.

B. Input Devices
1. Differential Pressure and Pressure Sensors shall have an output proportional signal with provisions for field checking. Sensors shall withstand up to 150% of rated pressure, without damaging the device. Accuracy shall be within +2% of full scale.
2. Water Differential Pressure Switches shall have a repetitive accuracy of + 2% of range and withstand up to 150% of rated pressure. Switch operation shall be adjustable over the operating pressure range. The switch shall have an application rated Form C, snap-acting, self-wiping contact of platinum alloy, silver alloy, or gold plating.
3. High static limit switch Switches shall be diaphragm operated with diaphragm to actuate a single pole double throw snap switch. Motion of the diaphragm shall be transmitted to the switch button by means of a direct mechanical linkage.
4. Static pressure sensor Provide a differential pressure transmitter with a 4-20 ma output to the BAS. It shall be capable of sensing very low positive, negative or differential pressures.

Accuracy: +/- 1% of range
Ranges: 5.0"/12.5mbar
Operating temp range: 32o to 125of
Operating humidity range: 20% to 90% RH non-condensing

5. Flow Switches shall have a repetitive accuracy of + 1% of their operating range. Switch actuation shall be adjustable over the operating flow range. Switches shall have snap-acting Form C contacts rated for the specific electrical application.
6. Flow Meter Provide brass Hot Tap flow sensor that features an elongated sensor, pipe nipple, and gate type isolation valve to allow the nonmagnetic impeller sensor to be installed into a pressurized pipe while the pipe is in service. Provide analog transmitter to convert the flow to a 4-20mA signal. Data Industrial 225B or approved equal.
7. Watt-hour Transducers. Watt-hour transducers shall have an accuracy of +1 % for kW and kWh outputs from full lag to full lead power factor. Input ranges for kW and kWh transducers shall be selectable without requiring the changing of current or potential transformers, and shall have dry contact pulse accumulation.
8. Voltage-to-Digital Alarm Relay shall monitor status of safeties and overloads and shall be sized and connected so as not to impede the function of the monitored contacts. Switch shall have self-wiping, snap-acting Form C contacts rated for the application.
9. Current Sensing Relays Relays shall monitor status of motor loads. Switch shall have self-wiping, snap-acting Form C contacts rated for the application. The setpoint of the contact operation shall be field adjustable.
10. Carbon Dioxide Sensors Sensor shall be duct mounted CO2 sensor that monitors the indoor levels of carbon dioxide in accordance with ASHRAE Standard 62-1989. Sensor shall have a 4-20mA output over a range of 0-2000 ppm of CO2. Accuracy shall be +/- 2.5% of reading or +/- 50 ppm, whichever is greater.
11. Timed Local Over-ride Provide a push button momentary normally open switch. Flush mount style.
12. Photocell Provide photocell with transmitter for 4-20 mA output signal. Sensor shall be mounted in a water proof enclosure. Unit shall be calibrated for 4 mA at greater than 100 foot-candles and 20 mA at less than 0.1 foot-candles.

C. Output Devices

1. Control Relays Control relay contacts shall be rated for 150% of the loading application, with self-wiping, snap-acting Form C contacts, enclosed in dust proof enclosure. Relays shall have silver cadmium contacts with a minimum life span rating of one million operations. Relays shall be equipped with coil transient suppression devices.
2. Solid State Relays (SSR). Input/output isolation shall be greater than 10 billion ohms with a breakdown voltage of 15 V root mean square, or greater, at 60 Hz. The contact operating life shall be 10 million operations or greater. The ambient temperature range of SSRs shall be 20°F-140°F. Input impedance shall be greater than 500 ohms. Relays shall be rated for the application. Operating and release time shall be 10 milliseconds or less. Transient suppression shall be provided as an integral part of the relays.

D. Miscellaneous : Provide and install all relays, switches, and all other necessary devices required for a complete and satisfactory operating system.

E. Modulating dampers shall have linear flow output characteristics. Frame: galvanized steel, minimum 13 gage, channel shaped for adequate strength. Blades: single blade up to maximum 8" wide; multiple blade, opposed-action for openings more than 8". Multi-blade dampers shall use blades not more than 8" in width. Blade material shall be galvanized steel, not less than 16 gage thickness, formed for extra strength. Provide replaceable edge seal, with spring loaded stainless steel side seal. Hardware: corrosion resistant zinc plated steel or brass. Bearings shall be acetal or oilite. For dampers mounted in ducts, provide extended shafts for externally mounted operators.

F. Automatic valves.

1. Pressure ratings: 125 psi or 1.25 times the maximum system operating pressure.
2. Construction:
   a. 1. 2" and smaller: Screwed. Bodies and internal parts: bronze, stainless steel or other approved corrosion-resistant metal.
   b. 2 ½" and larger: Flanged. Bodies: cast iron or cast steel. Seats and part exposed to fluid: bronze, stainless steel or other approved corrosion-resistant metal.
   c. Modulating straight through water valves: equal percentage contoured throttling plugs. Ball valves are not acceptable.
   d. Three way valves: linear throttling plugs allowing total flow through valve to remain constant regardless of position.
3. Sizes: By automatic control system manufacturer for fully modulating operation.
4. Minimum pressure drop: equal to pressure drop of coil or exchanger.
5. Maximum pressure drop: 5 psi
6. Relief and by-pass valves: sized according to pressure available.

7. 2-position valves: line size unless otherwise noted. Butterfly valves: may be used for valves 4" and larger.

G. Damper Actuators
1. Electronic direct-coupled actuation shall be provided. Spring return not required.
2. The actuator shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp assemble shall be of a 'V' bolt design with associated 'V' shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a 'V' clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up to 1.05 inches when the damper is constructed in this manner. Single bolt or screw type fasteners are not acceptable.
3. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.
4. Proportional actuators shall accept a 0 to 10VDC or 0 to 20mA control input and provide a 2 to 10VDC or 4 to 20mA operating range. An actuator capable of accepting a pulse width modulating control signal and providing full proportional operation of the damper is acceptable. All actuators shall provide a 2 to 10VDC position feedback signal.
5. All 24VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10VA for AC or more than 8 watts for DC applications. Actuators operating on 120VAC power shall not require more than 10VA. Actuators operating on 230VAC shall not require more than 11VA.
6. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb torque shall have a manual crank for this purpose.
7. All modulating actuators shall have an external, built-in switch to allow reversing direction of rotation.
8. Actuators shall be provided with a conduit fitting and a minimum 3ft electrical cable and shall be pre wired to eliminate the necessity of opening the actuator housing to make electrical connections.
9. Actuators shall be Underwriters Laboratories Standard 873 listed and Canadian Standards Association Class 4813 02 certified as meeting correct safety requirements and recognized industry standards.
10. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a 2-year manufacturer's warranty, starting from the date of installation. Manufacturer shall be ISO9001 certified.

2.15 OUTSIDE AIR MEASURING AND MODULATION DEVICE
A. Factory assembled damper, airflow monitor, actuator, and accessories.

2.16 WATER FLOW AIR MEASURING DEVICE
A. Factory assembled damper, airflow monitor, actuator, and accessories.

2.17 VARIABLE FREQUENCY DRIVES
A. ABB ACH550, DANFOSS VLT6000, YASKAWA, TOSHIBA Q7 FLOWSAVER or equal. Variable Frequency Drive mounted in a NEMA 1 enclosure with all of the below feature mounted and wired. LCD display keypad control, min. 3% input line reactor or 3% dc link reactor (harmonics meeting IEEE 519-1993), RFI/EMI Filters, adjustable acceleration and deceleration, auto restart with speed search, .95 true harmonic power factor correction, compatible with 4-20 ma or 0-10 vdc signal, electronic motor overload with phase to phase short circuit protection, ground fault protection, LCD display and keypad to include manual speed control with HOA operation, contact closure for remote alarm indication and run indication. Controls interface shall be BACnet, MODBUS, LON as dictated by control contractor

B. Manual bypass
1. Bypass is not required for airhandler fans
2. Bypass shall be provided for pumps

C. Line voltage Disconnects
1. An integral disconnect is only required in the VFD when the new VFD is installed :
   a. outside the line of sight between existing disconnect and new VFD, or
   b. outside the line of sight between new VFD and the existing controlled fan or pump

D. Addition of variable speed drives to existing airhandlers or fan coils includes:
1. Provision and installation of the VFD (after field confirming motor voltage and size)
2. Implementing the stipulated sequence of controls
3. Disabling the existing motor starter (but not it's disconnect functions) and moving interlock wiring to the VFD.
4. Disabling and locking face and bypass dampers (if applicable) to be fully open to the cooling coil; fully closed to the bypass

E. Addition of variable speed drives to existing pumps includes:
1. Provision and installation of the VFD (after field confirming motor voltage and size)
2. Opening balance valve to full open
3. Implementing the stipulated sequence of controls
4. Disabling the existing motor starter (but not it's disconnect functions) and moving interlock wiring to the VFD.

F. Addition of variable speed drives to existing 2 speed motors (such as cooling tower fans) includes wiring motor to high speed only

2.18 AIR SUPPLY PIPING AND TUBING

A. No new control air supply piping is anticipated; use this section only if repairs are required to Control and Instrumentation Tubing:
1. Copper Tubing: ASTM B280 Type ACR, or ASTM B88 Type K, seamless, hard drawn or annealed.
   a. Fittings: ASME B16.22, wrought copper.
   b. Joints: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.
2. Copper Tubing: ASTM B280 Type ACR, or ASTM B88 Type K, seamless, hard drawn or annealed.
   a. Fittings: UL listed, rod or forged brass rated to 200 psig at 100 degrees F.
   b. Joints: Ball sleeve compression type.
3. Polyethylene Tubing: Black, flame retardant, virgin polyethylene, conforming to modified ASTM D1693 test. Rated for use in return plenums
   a. Fittings: UL labeled, rod or forged brass rated to 200 psig at 100 degrees F.
   b. Joints: Compression or barbed type.

2.19 SECURITY AGAINST OUTSIDE ACCESS

A. Owner requires maximum protection against unauthorized hacking or access. Advise Owner's IT rep of measures taken, such as use of virtual private network (VPN).

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify conditioned power supply is available to control units and workstations.

B. Verify field end devices and wiring is installed prior to installation proceeding.

3.2 INSTALLATION

A. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.

B. Install software in control units and in workstations. Implement features of programs to specified requirements and appropriate to sequence of operation. Refer to Section 23 09 93.

3.3 FIELD QUALITY CONTROL

A. After completion of installation, test and adjust control equipment and sequences of operation. Submit data showing set points and final adjustments of controls.

B. Check calibration of instruments. Recalibrate instruments out of calibration. Advise owner of defective instruments.

3.4 PNEUMATICS

A. All pneumatic control lines within mechanical rooms or central plant shall be removed back to where the air main enters the mechanical room

1. Exception: air mains from remaining compressors and serving active devices shall remain

B. Outside mechanical rooms:
1. Pneumatic control lines within chases or above hard ceilings may be abandoned in place
2. Remove unused branches above lay- in ceilings

C. Cap all remaining pneumatic control lines. Bubble- test cap for air leakage.

D. Existing controls air compressors and driers to remain, no repairs, adjustments or replacements.

3.5 INTERCONNECTING WIRING and CABLING and POWER WIRING

A. Provide all wiring and transformers required for a complete BAS System.

B. BAS system wiring and cabling shall include but may not be limited to the following:
1. All power wiring required, whether not indicated or not on the plans and specifications.
2. Power to all actuators and sensors.
3. Wiring and cabling for network communications
4. Sensor and control device input and output wiring.
5. Interconnecting cabling between and amongst network devices, PCs, printers, etc.
6. Interlock wiring between devices and between motor starters.
7. All other necessary wiring for fully complete and functional system as specified.

C. Install and comply with the requirements of the Project Electrical System Specifications, the National Electric Code (NEC), and any/all applicable local codes and/or Authorities Having Jurisdiction (AHJ)

D. Install piping, wiring/cabling routed parallel to or at right angles with the structure, properly supported every six (6) feet at a minimum and installed in a workmanlike manner.

E. All wiring shall be installed as continuous links. Any required splices shall be made only within an approved junction box or other approved protective device with a maximum fill of 50%. BACnet network cabling shall not be field spliced

F. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

G. Terminate all control and/or interlock wiring and maintain updated (as-built) wiring diagrams with terminations identified at the job site.

H. Line voltage Power Wiring and Cabling
1. Provide power wiring for all control units, enclosures and equipment, input/output devices, including branch circuit wiring from circuit breaker panels and appropriately sized breakers
2. All power wiring shall have grounding conductor.
3. Wiring shall be in raceway systems and installed in accordance with the National Electric Code, applicable local codes and Authorities Having Jurisdiction
4. Server equipment shall be served from isolated ground receptacle via UPS by dedicated branch circuit
5. All other enclosures, sensor and control devices shall be fed from separate circuits in the electrical distribution panels and shall not be served from wall receptacle or lighting circuits.

I. Circuits on **Emergency Power Panels**: the following shall be powered from emergency power circuits: None

3.6 LOW VOLTAGE NETWORK WIRING AND CABLING

A. Strictly adhere to the manufacturer's networking installation instructions and procedures

B. Use only plenum-rated cables, even inside conduit

C. Cabling shall be in raceway or conduit when:
1. Exposed in mechanical and electrical spaces or shafts and within 8 ft of the floor

D. A separate color code shall be used for each low voltage wiring category below. Use same color code for entire project. Match existing color codes.
1. 24 VAC Power
2. Communications
3. Input/Output

E. Externally identify cabling or conduit as "Building Energy Management System Network" at regular intervals, not to exceed 25 ft.

F. Network installation shall conform to standards for the LAN types and cabling types selected. Specific network rules inherent to the ANSI/ASHRAE Standard 135-1995, BACnet will be followed. Those include but are not limited to:

1. Only one path can exist from any device to another
2. Each device connected to an internetwork LAN must have a unique device instance
3. Each internetwork LAN must have a unique Network Number
4. Wire type used for MSTP, RS-485 twisted pair communications must be balanced twisted pair with 100 to 120 Ohms Characteristic Impedance. The wire shall be less than 30 pF per foot, and preferred 22AWG or lower. A shield wire shall be included for ground connection.

G. Primary LAN Network wire and cable shall be run separately from all other wiring. Other LAN Network wire and cabling shall be installed separate from any wiring over thirty (30) volts.

H. All communications shielding shall be grounded as per manufacturer's recommendations.

I. Maximum allowable voltage for control wiring shall be 120-volts.

J. Wiring and cabling installed in and/or routed through Enclosures and Panels shall be fastened securely using cable ties, non-metallic wiring and/or other standard industry wiring management means and methods in a workmanlike manner parallel and/or perpendicular with enclosure.

K. All terminal panels, Enclosures, Sub-Panels, Junction Boxes, Pull Boxes, Troughs, Trays, Raceways, Conduits, &c. shall not exceed 70% maximum conductor fill.
L. Each Input/Output device shall be controlled from a dedicated 2-pair conductor

M. All wire within controls enclosure shall be neat and suitably bundled and contained in Panduit wire duct or equivalent

N. All wiring will be identified at controller and Input/Output device.

O. Conceal wiring and cabling, except in mechanical and electrical spaces.

P. Install parallel to or at right angles with the structure, properly supported and in a workmanlike manner.

Q. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

R. Terminate all control and/or interlock wiring and maintain updated (as-built) wiring diagrams.

3.7 MANUFACTURER'S REPRESENTATIVE FIELD SERVICES

A. Start and commission systems. Allow adequate time for start-up and commissioning prior to placing control systems in permanent operation.

B. Furnish service technician employed by system installer to instruct Owner's representative in operation of systems plant and equipment

3.8 DEMONSTRATION AND TRAINING

A. Demonstrate complete operation of systems, including sequence of operation prior to Date of Substantial Completion.

B. Furnish basic operator training for multiple persons (on multiple days) on data display, alarm and status descriptors, requesting data, execution commands and log requests. Include a minimum of 40 hours instructor time. This time shall be broken down to a minimum of eight
training sessions. The controls contractor shall submit a proposed training agenda to the Facility Manager prior to commencement of training. Training shall be performed on site.

C. Owner may video record the training sessions

D. Demonstrate complete and operating system to Owner.

E. Provide free and un-limited access to all applicable online tutorials during the warranty period.

3.9 COMMISSIONING

A. Assist Owner's Commissioning Agent in commissioning systems as follows:

1. Commissioning may be in phases and require multiple sessions
2. Place systems and equipment into full operation and continue operation during each working day of commissioning or testing.
3. Complete and endorse test checklists to assure equipment and systems are fully operational and ready for functional performance testing. .
4. Review sequences of operation and obtain clarification from Engineer.
5. Prior to functional performance tests, review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during tests.
6. Perform Functional Performance Tests, as directed by the Commissioning Agent.
7. Repeat failed tests until they pass

3.10 TREND LOGGING SCHEDULE

A. System shall be capable of logging all data points and of downloading logs into Excel format

B. Store a minimum of one month's data on the operator work station

3.11 INPUT/OUTPUT SCHEDULES

A. Separate spreadsheets list equipment and required control, monitoring and status points.

B. Provide all sensors or data input required by the Sequences of Operations, even if not specifically noted in the spreadsheets reference above

C. Not all air units are receiving new VFDs; however each new airhandler or fancoil local controller shall have the capacity to accept an input signal from a future duct pressure sensor and to output a future output signal to a VFD, based on a fan speed optimization algorithm

3.12 REPLACEMENT CONTROL PANELS FOR CHILLERS 1,2 &3 (BID ALTERNATE lump sum for installation of all three)

A. Provide YORK/JCI OPTIVIEW CONTROL PANEL, Microprocessor based, stand alone

B. Scope: chiller operation; monitoring of chiller sensors, actuators, relays and switches; display of all operating parameters

C. Capability: stable chiller operation at 36 °F leaving chilled water temperature without warnings or shutdowns; no freezing or slushing of chilled water.

D. Enclosure: lockable, NEMA 1

E. Information Display: 10.4" (minimum) color liquid crystal display (LCD) mounted on control panel enclosure door.

F. User interface: operating parameters displayed in a user-friendly, color and graphical format.

G. Keypad: universal type with soft-keys

H. Height: Eye level; readable and operable without the need for ladder or stool.

I. Temperature rating: 0 to 40 degrees Celsius

J. System status information: displayed on screen at all times, including the following as a minimum: System status

1. System details
2. Control source (remote or local)
3. User access level
4. Date and time
5. Startup sequence timer
6. Shutdown sequence timer

K. Status messages: in color according to importance, indicate the following as a minimum:

1. Ready to start
2. System prelube (with countdown timer)
3. Running and running mode (chilled water setpoint control or current limit control)
4. Coasting down (with countdown timer)
5. Safety shutdown – chiller requires manual restart

6. Cycling shutdown – chiller will automatically restart
7. Start inhibit and inhibit mode (anti-recycle, vane motor switch open, excess motor current)

L. System operating information, including the following as a minimum:
1. Return and leaving chilled water and condenser water temperatures
2. Evaporator and condenser refrigerant saturation temperatures
3. Evaporator and condenser pressure
4. Evaporator tube and condenser tube small temperature difference
5. Compressor discharge temperature
6. Oil sump temperature
7. Oil pump pressure differential
8. Percent of motor full load current
9. Number of compressor starts
10. Operating hours
11. Pre-rotation vane position
12. Refrigerant level position (condenser)

M. Programmable setpoints: including the following as a minimum:
1. Chilled liquid temperature (setpoint and range)
2. Chilled liquid temperature cycling offset (shutdown and restart)
3. Motor current limit (%)
4. Pull-down demand (limit and time)
5. Remote chilled liquid temperature (reset setpoint and range)

N. Schedule function: programmable six week schedule for starting and stopping the chiller, pumps and cooling tower

O. Warning Messages: the following, as a minimum:
1. Real time clock failure
2. Transducer errors
3. Refrigerant level out of range
4. Setpoint overridden
5. Condenser high pressure limit
6. Evaporator low pressure limit
7. Motor high current limit

P. Safety Shutdowns: trigger a safety shutdown for any of the following as a minimum:
1. Evaporator – low pressure
2. Condenser – high pressure
3. Condenser – high pressure contacts open
4. Auxiliary safety – contacts closed
5. Compressor discharge – high or low refrigerant temperature
6. Oil – high temperature
7. Oil – high or low differential pressure
8. Oil – pump pressure setpoint not achieved
9. Control panel – power failure
10. Motor or starter – current imbalance
11. Thrust bearing – high oil temperature
12. Thrust bearing – oil temperature sensor
13. Watchdog – software reboot
14. Sensor – failure or out of range
15. Transducer – failure or out of range
16. Motor controller – fault

Q. Safety Shutdowns: for each safety shutdown, indicate the following as a minimum:
1. System status and details
2. Day and time of shutdown
3. Cause of shutdown
4. Type of restart required

R. Cycling Shutdowns: indicate the following as a minimum:
1. Multiunit cycling – contacts open

2. System cycling – contacts open
3. Oil – low temperature
4. Oil – low temperature differential
5. Control panel – power failure
6. Leaving chilled liquid – low temperature
7. Leaving chilled liquid – flow switch open
8. Condenser – flow switch open
9. Motor controller – contacts open
10. Motor controller – loss of current
11. Power fault
12. Control panel – schedule

S. Security Access: through ID and password recognition defined by a minimum of three different levels of user capability:
1. View: prevent unauthorized changing of setpoints
2. Operator: allow local or remote control of chiller

T. Service: allow manual operation of pre-rotation vanes and oil pump

U. Chiller information screen: on-screen display of:
1. Model number
2. Chiller serial number
3. Control panel serial number
4. Manufacturer contract number
5. Design voltage
6. Refrigerant type
7. Starter type
8. Original factory rating information (per ARI rating)
9. Data tracking and trend display: on-screen graphical display of:
10. Parameters selected from a list of a minimum of 100 possibilities
11. Data collected once per second up to once per hour for each parameter
12. Data trend lines displayed for a minimum of 5 parameters at once

V. History: store last ten shutdowns and display all system parameters at the time of shutdown

W. Memory: non-volatile type containing operating program and setpoints, capable of retention for 10 years without memory loss, despite AC or backup battery power loss.

X. Overcurrent protection: fused connection through a transformer in the motor starter panel to protect all controls

Y. Terminal Strip: clearly numbered to accept field interlock wiring

Z. Remote communications: via electrical contacts, control panel capability to indicate the following as a minimum:
1. Ready to start contacts
2. Safety shutdown contacts
3. Cycling shutdown contacts
4. Running contacts

AA. Remote communications: via 4-20 mA or 0-10V analog signals, control panel capability to adjust the following as a minimum:
1. Leaving chilled liquid setpoint
2. Current limit setpoint
3. Chiller start and stop

BB. Data logging and printing: via RS-232 or similar, control panel capability for exporting at user-programmable intervals:
1. All system operating data
2. Shutdown and cycling messages
3. Operating details of last 10 cycling or safety shutdowns

CC. Units of measure: capable of displaying in either English or Metric units

END OF SECTION

SECTION 23 09 93
SEQUENCE OF OPERATIONS FOR CONTROLS

PART 1 GENERAL

1.1 SUMMARY

A. Related Sections:
1. Section 23 09 23 - Direct-Digital Control System for HVAC: For equipment, devices, system components, and software to implement sequences of operation.

1.2 INTENT
1. It is intended that NEW sequences of control be added for all equipment in this section. Duplication of existing sequences is NOT the intent, unless specifically stated in the following sections.

2. If a sequence is not described in the section, the existing sequence shall be documented and submitted for revision/comment and approval. Make and implement the approved sequence.

3. All existing TIME SCHEDULES are to be documented and submitted for revision/comment and approval. Make and implement the approved schedules.

4. Custom programming of sequences is discouraged; the intent is to use vendor's proven algorithms that accomplish the intent of the sequences described below; deviations specific algorithm steps or methods are allowed

1.3 SUBMITTALS
A. Shop Drawings: Indicate system controlled and control system components.
1. Submit written description of all EXISTING CONTROL SEQUENCES, even if that sequence is being changed as part of this project
2. Submit written description of NEW CONTROL SEQUENCES
a. Submit flow diagrams for each control system, graphically depicting control logic.

1.4 CLOSEOUT SUBMITTALS
A. Project Record Documents: Record actual locations of components and set points of controls, including changes to sequences made after submission of shop drawings.

1.5 PARTICIPATION IN DISCUSSION OF SEQUENCES
A. Participate in up to 3 meeting with Owner and Engineer to discuss refinements / improvements to sequence of operations.

1.6 DEMONSTRATION OF SEQUENCES
A. Each sequence of operation that applies to multiple units (such as airhandlers) shall first be implemented on a single unit as a test for Owner, CX agent and Engineer. Make requested revisions or refinements. Upon Owner's approval, the sequence shall then be applied to all such units.

1.7 ABBREVIATIONS : 'BAS' = BUILDING AUTOMATION SYSTEM

PART 2 PRODUCTS
Not Used.

PART 3 EXECUTION
3.1 GOALS- ALL SYSTEMS: automatically start, stop, stage and sequence equipment in a manner that:
1. Satisfies building loads
2. Minimizes total system energy use using established techniques such as those ASHRAE 2011 Applications Chapter 42
3. Does not interfere with or override equipment safeties or recommended procedures
4. Operates equipment within manufacturer's recommended ranges and parameters
5. Achieves equal run times on like equipment

3.2 CHILLED WATER SYSTEM (VARIABLE PRIMARY FLOW) :

A. The building operator shall have the option to operate the chilled water plant manually or automatically.

B. The chilled water system consists of 4 water cooled chillers:
1. CH-1
2. CH-2
3. CH-3
4. CH-4:

C. There are 4 manifolded (primary) chilled water pumps, variable volume
1. CHWP -1
2. CHWP -2
3. CHWP -3
4. CHWP -4

D. There are 4 manifolded condenser water pumps, constant volume
1. CHWP -1
2. CHWP -2
3. CHWP -3
4. CHWP -4

E. Each chiller has a motorized isolation valve on chilled and condenser water; isolation valves shall be open when chiller is active e; closed when inactive.

F. Each water pump and chiller has a starter with Hand-Off-Auto (HOA) switch. When in the Auto mode, the pump or chiller controlled shall be stopped and started by the BAS.
When the HOA switch is in the Hand position, the pumps or chiller shall be manually started, subject to safety interlocks

G. Manual Chilled Water Operation

1. Each set of chilled and condenser water pumps (1 set per chiller) is individually started by command from the BAS. Each chiller shall be hardware interlocked with its respective pumps to start 20 seconds after the differential pressure switches in the chilled and condenser water piping to that water chilling unit indicate proper flow conditions.

2. After each unit is started, it shall be individually controlled by the factory furnished controller to maintain the selected constant chilled water supply temperature. When the chilling unit is stopped, its chilled water pump shall shutoff.

3. If the chiller continues to operate following shutdown of the either water pump, then an appropriate alarm shall be generated.

H. Automatic Operation of Water Chilling Units

1. The plant runs 24/7/365

2. The operating order of the chillers shall be determined by a lead/lag1/lag2/lag3 selector. The lead/lag sequence of the chillers shall be rotated on a schedule selected by the Owner. When the operating chillers exceeds 95% (adjustable) of its capacity, as measured by a current sensor, and the return water temperature exceeds setpoint, the next lag chiller and its pumps are energized.

3. Lag chilled water pumps are automatically stopped and its respective chiller's controls are de-energized when active chillers fall below a set percentage of their total capacity and chilled water return falls below setpoint.

4. A chiller must run for 20 minutes before it can be de-energized.

5. The building CHW supply temperature may be reset. Each air handler controller will transmit a signal to the chiller manager that indicates its cooling requirements. Any area of the building that is in its maximum cooling position will transmit a signal to the chiller manager to provide additional cooling. The chiller manager shall compile all of the information received and reset the building chilled water supply setpoint as required.

6. The chillers are equipped with factory operating and safety controls.

I. Plant Bypass- there is an existing 4'' motorized bypass valve in the plant between supply and return loops; it shall be programmed to maintain minimum flow through active chillers

J. The intent is to maintain minimal flow to the remote ends of all major chilled water branches (so that when an AHU needs chilled water it doesn't have to wait a long time for water to get there)

1. Some branches have 3 way valves at the end; but others do not.

2. For the branch without 3way valves, selected 2 way valves in inactive airhandlers remote from the plant shall be programmed to open (the fan will still be off) to maintain branch flow

K. CHILLED WATER RESET & PUMP SPEED CONTROL

1. Implement the ''Near-Optimal Chilled-Water Set Point" strategy described in 2011 ASHRAE Applications Chapter 42, pages 42.27 thru 42.29

3.3 CONDENSER WATER SYSTEM:

A. COOLING TOWERS (3 fans)

1. Each cooling tower fan has starter with HOA switch. When in Auto position, the fan shall be stopped and started by the BAS.

2. Each fan has a VFD.

3. Operate all active cells with fans at equal speeds (down to minimum speed allowed by the VFD, then drop off towers to keep above active VFD minimum speeds. Rotate lead /lag1/lag2 designation). Do not stage fans on/off sequentially.

   a. Shut fan down and send alarm if vibration switch indicates excessive vibration

   b. Activate basin heaters to maintain minimum basin setpoint; heater may only be activated with ambient temperatures are less than 40F. Send alarm if basin temperature is less than 40.

4. Outdoor air dry bulb, dew point and condenser water supply temperature shall be input into the BAS. A proportional plus integral DDC control algorithm shall provide condenser water setpoint reset via a digital output for each cooling tower fan and output to the condenser water bypass valves. Maintain a condenser water temperature as selected by the chiller optimization program.

5. An appropriate alarm shall be generated on failure of a fan to start, stop, or change speeds.

B. CHILLED WATER RESET & PUMP SPEED CONTROL

1. Implement the 'Near-Optimal Condenser Water Flow Distribution'' strategy described in 2011 ASHRAE Applications Chapter 42, pages 42.30 thru 42.33

3.4 BID ALTERNATE: CHILLER PLANT OPTIMIZATION PACKAGE

A. As a **Bid Alternate** Provide and implement a chiller plant optimization program which :

1. Seeks the lowest combined energy use from chillers, pumps and tower fans, subject to the minimum water temperatures or flows allowed at the active chillers
2. Establishes the optimum number and which chillers and towers to activate

B. Optimization program shall be a standard product of the vendor and shall have been applied to at least 20 central plants

C. Acceptable programs include, but are not limited to:

1. Johnson Controls
   a. JCI CPO 10
   b. JCI CPO 30
2. Optimum Energy – using Hartman Loop algorithms
3. Armstrong Pumps - using Hartman Loop algorithms

D. Plant optimization shall include measurement and verification

3.5 HYDRONIC HOT WATER SYSTEM
A. The hot boilers and hot water pumps shall be started upon a demand for heating from any zone. System will only be able to be energized if it is below its operator adjustable outdoor air lock out.

B. The hot water supply temperature shall be automatically reset by requests for additional heating from any zone. BAS shall modulate the hot water 3 way blending valve to maintain the desired building supply temperature. The system supply water temperature shall not be allowed to drop below 135 degrees (operator adjustable).

C. The boiler start circuit shall energize building hot water pumps and the individual boiler circulating pumps and isolation valves; then when the boiler controls have determined that all safeties have been met, the boiler(s) shall start. Boilers shall also be interlocked with the hot water pump flow switch which must prove flow prior to boiler start-up.

D. Boiler hot water individual circ pumps shall be controlled by a starter mounted HOA switch with the Auto position wired for starting, from the Building Automation System, by the controls of the boiler. An off delay relay shall be wired through the controls of the boiler to allow the boiler to fully shutdown for 5 minutes (adjustable) before the pumps are shut down. An additional interlock shall be provided such that the pumps cannot be shut down via HOA switch while the boiler is operating.

E. The hot water boiler shall be automatically fired and shall be regulated by the internal controls furnished by the boilers. All safety controls for the boiler shall be furnished by the boiler manufacturer. Boiler gas train controls and required safety interlocks shall be connected.

F. Lead/lag of the boilers shall be by the BAS.

G. Energy management system shall annunciate alarm condition at boilers.

H. In "hand" position, the boiler shall be manually energized, and the pumps shall be operated from the motor starter.

3.6 CONSTANT VOLUME, SINGLE ZONE, 4 PIPE AIR HANDLING or FAN COIL UNITS:
A. These units consist of a fan, chilled water and hot water coils. The space temperature sensor shall modulate the chilled and hot waters valve in sequence to maintain the cooling and heating space setpoints (separated by a dead band).

1. On units with face and bypass damper, the chilled water coil is controlled to a constant coil leaving air temperature (55F adjustable) and face and bypass dampers modulate to satisfy the zone calling for most cooling

B. If air unit has a 2 speed fan motor, then low speed is selected when all zone are calling for less that 50% full cooling

C. AHU shall have an optimum start algorithm that learns how long it takes to achieve space conditions based on ambient temperature and fan speed.

D. Existing fire alarm duct detectors are to remain and not interface with the BAS.

E. Dehumidification:

1. If unit has heating coil in the reheat position then a dehumidification sequence (full or reduced cfm cooling, plus reheat) shall be programmed now, and capable of activation by Owner by checking a box or similar simple instruction, plus addition of future humidistat.

F. If a VFD is added to the unit, then control the VFD via the following algorithm:
1. Cooling mode :
   a. Leaving air set point is maintained at 55F (adjustable)
   b. Fan speed is automatically adjusted to maintain space setpoint , down to minimum speed of 40% (adjustable)
2. Heating mode :
   a. Fan is at minimum setting
   b. Heating coil stages (electric) or modulates (hot water) to maintain leaving air at 90F (adjustable) or less
   c. If space is not satisfied, fan speed increases

G. Associated motorized outside air damper is full open when unit is active; closed when unit is inactive.

1. Unit with CO2 based demand control ventilation shall modulate outside air damper to maintain CO2 setpoint

H. Freeze Protection: A low limit space or return air thermostat on sensing 45°F temperature (adjustable) shall close outside air damper and activate an alarm.

3.7 VARIABLE VOLUME, SINGLE ZONE, 4 PIPE AIR HANDLING or FAN COIL UNIT:

A. These units consist of a fan, chilled water and hot water coils.

B. Control the VFD via the following algorithm:
1. Cooling mode :
   a. Leaving air set point is maintained at 55F (adjustable)
   b. Fan speed is automatically adjusted to maintain space setpoint , down to minimum speed of 40% (adjustable)
2. Heating mode :
   a. Fan is at minimum setting
   b. Heating coil stages (electric) or modulates (hot water) to maintain leaving air at 90F (adjustable) or less
   c. If space is not satisfied, fan speed increases

C. AHU shall have an optimum start algorithm that learns how long it takes to achieve space conditions based on ambient temperature and fan speed.

D. Existing fire alarm duct detectors are to remain and not interface with the BAS.
1. Outside air damper is full open when unit is active; closed when unit is inactive. Damper and operator shall be capable of full modulation (to allow future addition of demand control ventilation)

E. Dehumidification:
1. If unit has heating coil in the reheat position, then a dehumidification sequence (full or reduced cfm cooling, plus reheat) shall be programmed now, and capable of activation by Owner by checking a box or similar simple instruction, plus addition of future humidistat.

F. Associated motorized outside air damper is full open when unit is active; closed when unit is inactive.
1. Unit with CO2 based demand control ventilation shall modulate outside air damper to maintain CO2 setpoint

G. Freeze Protection: A low limit space or return air thermostat on sensing 45°F temperature (adjustable) shall close outside air damper and activate an alarm.

3.8 MULTIZONE AIR HANDLING UNIT

A. These units consist of a fan section , cold (chilled water) deck , hot (hot water) deck and multiple zone dampers

B. The chilled water valve shall modulate to maintain cold deck leaving temperature of 55F

C. If there is a demand for heating, the hot water valve shall modulate to maintain a hot deck leaving temperature of the lowest temperature that satisfies all zones, but not to exceed 90 F. If no zones demand heating, the hot water valve is closed

D. Zone dampers modulate air between cold and hot decks to maintain space setpoints

E. Control Fan speed :
1. Intent: control to the lowest speed that satisfies all zones
2. Check the controller outputs for all zone dampers and determine time-averaged values over the last decision interval.
3. If any of the controller outputs are greater than a threshold value (e.g., 95%), then increase the static pressure set point by a fixed value (e.g., 5% of the design range) and go to Step 4. Otherwise, go to Step 3.
4. If all of the controller outputs are less than a threshold value (e.g., 85%), then decrease the static pressure set point by a fixed value (e.g., 5% of the design range) and go to Step 4. Otherwise, do not change the set point.
5. Limit the set point between upper and lower limits based on upper and lower flow limits and the duct design.

F. Associated motorized outside air damper is full open when unit is active; closed when unit is inactive.
1. Units with CO2 based demand control ventilation shall modulate outside air damper to maintain CO2 setpoint

G. Freeze Protection: A low limit space or return air thermostat on sensing 45°F temperature (adjustable) shall close outside air damper and activate an alarm.

H. AHU shall have an optimum start algorithm that learns how long it takes to achieve space conditions based on ambient temperature and fan speed.

I. Existing fire alarm duct detectors are to remain and not interface with the BAS.

3.9 TEXAS MULTIZONE AIR HANDLING UNIT

A. These units consist of a fan section , cold (chilled water) deck , neutral bypass deck and multiple zone dampers and duct mounted hot water coils

B. The chilled water valve shall modulate to maintain cold deck leaving temperature of 55F

C. Zone dampers modulate air between cold and neutral decks to maintain space setpoints

D. If all zone air is bypassing the cold deck and there is a heating demand, the hot water valve shall modulate open to maintain space temperature. However zone duct temperature shall not exceed 90 F.

E. Control Fan speed :
1. Intent: control to the lowest speed that satisfies all zones
2. Check the controller outputs for all zone dampers and determine time-averaged values over the last decision interval.
3. If any of the controller outputs are greater than a threshold value (e.g., 95%), then increase the static pressure set point by a fixed value (e.g., 5% of the design range) and go to Step 4. Otherwise, go to Step 3.
4. If all of the controller outputs are less than a threshold value (e.g., 85%), then decrease the static pressure set point by a fixed value (e.g., 5% of the design range) and go to Step 4. Otherwise, do not change the set point.
5. Limit the set point between upper and lower limits based on upper and lower flow limits and the duct design.

F. Associated motorized outside air damper is full open when unit is active; closed when unit is inactive.
1. Units with CO2 based demand control ventilation shall modulate outside air damper to maintain CO2 setpoint

G. Freeze Protection: A low limit space or return air thermostat on sensing 45°F temperature (adjustable) shall close outside air damper and activate an alarm.

H. AHU shall have an optimum start algorithm that learns how long it takes to achieve space conditions based on ambient temperature and fan speed.

I. Existing fire alarm duct detectors are to remain and not interface with the BAS.

3.10 PRETREATED OUTSIDE AIR UNITS

A. These units consist of a fan and chilled, hot water coils and motorized damper.

B. Each unit shall have separate on/off schedule and may be programmed by Owner (without special software or training) or to be software interlocked with any AHU or AHU group. Interlock shall include the ability to program OA unit start/stop offset by a selected time period before or after the AHU group start or stop.

C. When unit in on: intake outside and associated AHU outside air dampers are open. When unit is off: intake damper is closed and associated AHU outside air dampers are closed.

D. The leaving air temperature sensor shall modulate the chilled and hot water valves in sequence to maintain leaving air setpoint. Leaving air setpoint shall be reset based on ambient temperature and

E. Local hot water circ pump shall active when unit is in heating mode

F. Freezes stat shall alarm when air entering cooling coil is below 45 F. If air entering cooling coil is below 38 F, damper shall close and fan shall shut off

G. For unit with existing or new VFDs:

1. Fan speed shall be controllable based on time of day, expected occupancy schedule or input from a new or existing CO2 sensor (addition of new CO2 sensors is not part of this project)
2. Fan minimum speed is adjustable, and minimums programmed based on maintaining positive building pressurization (as measured at 3 building public entrances)

3.11 ELECTRIC DUCT HEATERS

A. Stage duct mounted heating coils to maintain space setpoint .For zones with both air valve and duct heater, do not activate heater until air valve goes to 'heating' position (the lowest cfm that provide required heater air flow).

3.12 DOMESTIC WATER PUMPS

A. Typically these run 24/7/365; however capability shall be provided to schedule start and stop via the BAS.

B. Pressure control is via controls integral with the pump controller

3.13 DOMESTIC HOT WATER PUMPS

A. Each pump shall have individually schedulable start and stops via the BAS.

3.14 CENTRAL EXHAUST AND VENTILATION FAN SYSTEMS

A. Time Schedule: Start and stop fans. Determine fan status. When fan fails to start as commanded, signal alarm.

B. For fans with thermostat: On room temperature above 85 degrees F, open intake dampers and start exhaust fans.

3.15 DEMAND CONTROLLED VENTILATION

A. Certain air units have existing CO2 sensor and modulate outside air dampers based on Co2 levels. Maintain existing sequences and setpoints.

3.16 SMOKE DETECTORS

A. All existing unit or duct mounted supply or return air smoke detectors shall remain. Maintain existing interlocks.

3.17 FREEZESTATS

A. All existing air unit freeze stats shall remain. Maintain existing interlocks.

3.18 HUMIDITY CONTROL

A. Any existing humidification or dehumidification sensors and controls shall remain. Maintain existing sequences and setpoints.

3.19 SOFTWARE INTERLOCKS

A. Any existing interlocks between equipment shall remain.

3.20 CENTRAL PLANT LOUVER

A. Louver may be scheduled open or closed via the BAS based on time of day, plant temperature or software interlock with selected fans , boilers or other equipment

3.21 SPACE HEATERS

A. Maintain existing sequence

B. Fan to start when calling for heating

3.22 LIGHTING

A. Each lighting contactor channel may be scheduled On or Off individually using a dedicated schedule or scheduled as a group via the BAS.

3.23 LIFE SAFETY SMOKE EXHAUST OR PRESSURIZATION FAN SYSTEMS

A. No control by the BAS; all control functions are accomplished via the existing fire alarm systems

END OF SECTION

CODE INFORMATION:

APPLICABLE CODES INCLUDE BUT ARE NOT LIMITED TO:

CITY OF HOUSTON BLDG CODE: 2006 IBC, AMENDED
CITY OF HOUSTON MECHANICAL CODE: 2006 UMC, AMENDED
CITY OF HOUSTON ENERGY CODE: ASHRAE 90.1- 2007, COH AMENDED

ENERGY CODE PER ASHRAE / IES 90.1-2007- MANDATORY PROVISIONS

6.4.2 CONTROLS 6.4.2.1 A DEAD BAND OF AT LEAST 5 DEGREE SHALL BE SET, WITHIN WHICH ENERGY IS REDUCED TO A MINIMUM.

6.4.2.2 HEAT SETPOINT CANNOT EXCEED COOLING SET POINT

6.4.2.3 AUTOMATIC SHUT DOWN AND SETBACK CONTROLS ARE PROVIDED.

OPTIMUM START IS PROVIDED FOR SYSTEMS > 10000 CFM
ZONE ISOLATION CONTROLS ARE REQUIRED.

ENERGY CODE PER ASHRAE / IES 90.1-2007- PRESCRIPTIVE METHOD PROVISIONS
6.5.4.3: CHILLED AND HOT WATER SYSTEMS OVER 300000 BTUH SHALL HAVE AUTOMATIC TEMPERATURE RESET

GENERAL NOTES
- CONTRACTOR SHALL SUBMIT DRWGS FOR ALL PERMITS IN A TIMELY MANNER AND PAY ALL PERMIT FEES
- SEAL ALL PENETRATIONS OF FLOORS, RATED WALLS, EXTERIOR WALLS
- PROVIDE ANY REQUIRED TEMPORARY UTILITIES
- SELECT AND INSTALL ALL EQUIPMENT TO PROVIDE CLEARANCE CONFORMING TO MANUFACTURER'S MINIMUM RECOMMENDED SPACE FOR MAINTENANCE AND/ OR AIR FLOW AND SUFFICIENT TO ALLOW INSPECTION, SERVICE, REPAIR OR REPLACEMENT WITHOUT REMOVING ELEMENTS OF PERMANENT CONSTRUCTION OR DISABLING THE FUNCTION OF FIRE RESISTANCE RATED ASSEMBLIES.
- DO NOT RUN DUCT OR PIPE ABOVE ELECTRICAL PANELS
- ONLY OWNER'S REPRESENTATIVE MAY SHUT OFF EQUIPMENT OR DISCONNECT UTILITIES
- VISIT SITE PRIOR TO BID--NO EXTRAS WILL BE ALLOWED FOR CONDITIONS THAT COULD BE READILY OBSERVED

23 05 00 BASIC MECHANICAL REQUIREMENTS
Demolition: Damage to existing materials/equipment will be repaired at no additional cost. Offer demolished equipment to Owner, dispose of if Owner does not want.

Warranty: Guarantee labor and materials for minimum 1 year. Warranties begin upon Owner's acceptance of substantial completion of the installation.

Shop drawings: Submit complete information on all controls.

Operations and maintenance instructions: Provide 3 copies of operation and maintenance manuals to Owner. Provide within 90 days after the date of system acceptance. These manuals shall be in accordance with industry-accepted standard such as ASHRAE Guideline 1 and shall include, at a minimum, the following: (a) Controls system maintenance and calibration information, including wiring diagrams, schematics, and control sequence descriptions. Desired or field-

determined setpoints shall be permanently recorded on control drawings at control devices or, for digital control systems, in programming comments. Provide instruction on system operation to Owner's representatives.

Record drawings: Within 90 days after the date of system acceptance, provide record drawings in AutoCAD 2014 or higher, plus full size hard copy. Electronic backgrounds may be available from Owner for a fee. Record drawings shall include as a minimum the installed location of each control sensor and control panels.

Access doors: Provide *Milcor* or equal as required for access to all controls, dampers or other devices requiring attention. Doors shall match wall or ceiling rating. Architect must approve location and appearance of all access doors. Access panels for fire or smoke dampers shall be openable without the use of tools.

Sleeves: Provide metal sleeves where pipes or control wiring penetrate walls

23 05 03 PIPES FOR HVAC PIPING AND EQUIPMENT
Chilled or hot water-schedule 40 ASTM A53 black steel; or type L or M copper. System shall be rated for 150 psi.

Steel Joints: Threaded, welded or roll-grooved (do not use cut-groove). Welded joints will be full circle butt-weld joints to ANSI/ASME B31.9 latest edition. No other welded joints will be allowed. Backing rings are not be allowed

Steel fittings: ASME B16.3, malleable iron or ASTM A234/A234M, forged steel welding type. Thread-o-lets, Weld-o-lets, grooved fittings also allowed.
Couplings, Caps, Plugs: ANSI Class 3000, ASTM 181 Class 70, ANSI B16.11.
Nipples for Drains, Vents, Gauges: Sch 80, ASTM A53 Grade B seamless.
Unions: ANSI Class 3000, forged steel, steel-to-steel ground joints, ASTM 105.
Flanges: ASTM A105, flat face ANSI Class 150. Bolts and Nuts: Stud bolts, carbon steel, semi-finished with heavy hex nuts, ASTM A307 Grade B. Gaskets: Full face, red rubber or inorganic fiber (non-asbestos) gasket, ANSI B16.21.

Copper pipe fittings: ASME B16.18, cast brass, or ASME B16.22 solder wrought copper. Tee Connections: Mechanically extracted collars with notched and dimpled branch tube. Joints: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F. Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy with melting range 1190 - 1480 degrees F.

23 05 23 VALVES FOR HVAC PIPING
Ball valves: Nibco Scott 580 NIB SEAL or eq. two piece, fullport, bronze body**,** stainless steel trim, memory stop, insulated handle.

23 05 29 HANGERS AND SUPPORTS FOR HVAC PIPING & EQUIPMENT
Pipe, duct and equipment hangers and supports shall be per the local code. Support piping at a minimum every 10' or less for 1" and larger pipe, every 6' on 3/4" or smaller. With copper pipe use copper hangers or tape at contact point.

23 05 48 VIBRATION CONTROLS FOR HVAC PIPING & EQUIPMENT
New or revised Pipe: vibration isolate in same manner as existing pipe

23 05 53 IDENTIFICATION FOR HVAC PIPING
For motorized valves: Install engraved metal tags with corrosion resistant chain. Tag valves same as tagged on the BAS screen.

23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC
No air balance or water balance is required

23 07 01 PIPING INSULATION
Pipe insulations, mastics and jackets located in environmental air plenums shall have maximum flame spread index of 25 and maximum smoke developed index of not exceeding 50 in accordance with ASTM E84.
Chilled water- Closed cell insulations only (fiberglass is not acceptable) with vapor barrier sealant at all seams, joints and butts. Acceptable products are:

1. Koolphen 'K' or Resolco Insul-Phen phenolic foam with factory applied vapor retarder jacket
2. Pittsburgh Corning Foamglas. A vapor retarder jacket is not required, but a foil scrim kraft type All Service Jacket for decorative/ abuse purposes shall be provided.

For pipes not in environmental air plenums, the following may also be used:

3. Dow Trymer polyisocyanurate with factory applied vapor retarder jacket

Minimum installed R value or thickness shall be per the local energy code. For ASHRAE 90.1 -2004, Table 6.8.3: minimum 0.5'' for pipes 1.0" or smaller; minimum 1'' for pipes 1.5"or larger (based on conductivity not exceeding .28 Btu per inch/hr-ft-degree F).

Insulation thickness shall also be of sufficient thickness to result in NO external surface condensation under the following conditions; as calculated by current version of 3E Plus® Insulation Thickness Computer Program developed by the North American Insulation Manufacturers Association (NAIMA)(submit calculations):

1. Chilled water temperature, degrees F: 42
2. Surface emittance of the submitted and approved jacket
3. Wind velocity: pipes outdoors: 15 miles per hour; pipes inside bldg : 0 mph
4. Ambient conditions:
   a. pipe indoors, but in non-conditioned areas: 90 degree F. and 90% relative humidity
   b. pipes inside the conditioned building shell: 80 degrees F. and 75% relative humidity

Vapor retarder jackets shall be:

1. Indoors and hidden from public view (i.e. above ceilings, in chases, or in mechanical rooms) : foil (or polypropylene)-scrim -kraft type All Service Jacket (ASJ) with self sealing lap; or Venture Clad 1577CW self adhesive zero perm vapor barrier jacket; white
2. Where specified to be painted: foil scrim kraft type All Service Jacket with self sealing lap; white
3. Where visible to the public, but not painted (mechanical rooms are not 'public'): Venture Clad 1577CW self adhesive zero perm vapor barrier jacket; standard color and finish as selected by Engineer
4. Outdoors: Venture Clad 1577CW self adhesive zero perm vapor barrier jacket; silver or white

Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor retarder adhesive or PVC fitting covers.

Secure factory-applied vapor retarders and jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Do not use staples.

Secure field-applied jackets with manufacturer's published method, such as bands and mastic; do not use staples or other methods that penetrate the jacket.

Follow manufacturer's instructions for field-applied vapor retarders.

At locations, size and spacings recommended by insulation manufacturer, provide: a) galv. steel shield between outside of pipe jacket and pipe support ; b) insert of compression resistant insulating material between support shield and piping and under finish jacket.

Install vapor stops at all changes in configuration such as elbows, flanges, valves, and insulation terminations and all locations on piping and equipment requiring maintenance including instrumentation connections. Vapor stops are also required where straight pipe runs exceed 24 ft between pipe supports. Vapor stops shall be constructed using reinforced vapor barrier mastic. When the vapor stop is dry, the adjacent layer of insulation shall be installed using joint sealer.

Vapor Barrier Mastic: Vimasco Vapor-Block, Fosters 30-80, #749 or Childers' Chil-Perm #CP-35, or as recommended by insulation manufacturer. Use to seal all fittings, valves, heads and equipment insulation prior to application of outer covering. Water-based, compatible with the insulation material and flexible at the environmental temperature.

Heating hot water-1.5" fiberglass with all service jacket; or 1.5" Dow Trymer 2000 polyisocyanurate foam with Saran 540 vapor retarder film and Saran 520 Vapor Retarder Tape or all service jacket. Pipe unions may be uninsulated.

23 07 03 DUCTWORK INSULATION

If ductwork insulation is removed to install control devices, repair insulation to match existing type and finishes

23 25 00 CHEMICAL WATER TREATMENT

Closed System Treatment (chilled and hot water): by Owner
Open system (cooling towers): by Owner

23 31 00 HVAC DUCTS

If ductwork is modified or cut to install control devices, repair and seal to match existing type and finishes.

23 40 00 HVAC AIR CLEANING DEVICES
Construction filters in air handlers and / or temporary filter media over return or exhaust grilles are not required. Replacement of filters after work is complete, if required, will be by Owner.
----------end----------

ELECTRICAL SPECIFICATIONS
Applicable codes include but are not limited to: City of Houston Electrical Code

Basic Electrical Requirements

Permits and Codes: Obtain and pay for all necessary permits and required inspections. Comply with all national, state and municipal laws, codes and ordinances relating to building and public safety. Provide any required temporary power and utilities for all trades. Provide temporary construction lighting and power. All temporary electric shall be in accordance with OSHA Construction Standards 29FCR, Part 1926 and Article 305 of the National Electrical Code. Temporary lighting and power shall be provided in accordance with OSHA standards. The OSHA minimum illumination is 5 footcandles in general construction areas, and 10 FC in mechanical / electrical rooms and workrooms.

Visiting the Job Site: Visit the site of the proposed construction in order to fully understand the facilities, difficulties and restrictions attending the execution of the work. No additional compensation will be allowed this Contractor for work or items omitted from his original proposal due to his failure to inform himself regarding such matters affecting the performance of the work in this contract or necessary for the installation and completion of the work included herein.

Material: All materials shall be new, made in USA and U.L. listed. Material installation shall comply with NEC requirements and perform by craftsman skilled in this particular work.

Equipment Protection: Protect equipment and work from damage during handling and installation until completion of construction.

Cooperation with other Trades: Cooperation with trades of adjacent, related or affected materials or operations, is a part of this work in order to effect timely and accurate placing of work and to bring together, in proper and correct sequence, the work of such trades. Provide other trades, as required, all necessary templates, patterns, setting plans and shop details for the proper installation of the work and for the purpose of coordinating adjacent work. Verify characteristics of all equipment with other Divisions before roughing in the electrical connections and energizing the equipment. Remove any improperly installed electrical eqpt and conduit that are limiting proper access for eqpt service and maintenance.

Access Panel: Provide access panels or doors for all devices requiring adjustment. Similarly for all junction boxes, pull boxes etc that are required to be accessible per Code and/or the local authority having jurisdiction. Appearance of access panels/doors shall be acceptable to Architect. Panels/doors shall be designed for the fire rating of wall or ceiling in which they are installed. All access panels shall be lockable and shall be keyed alike (same keying as panels from other divisions).

Work in Occupied Areas: Work in, above, below or near occupied areas shall be at Owner's convenience and may be during evenings or weekends. Schedule all required power outages a minimum of 7 days in advance with Facility Engineer. Do not turn off any power sources. Only Facility Engineer or his authorized representative may do so.

Electrical Service Outage: Service to the existing building shall be maintained during normal working hour or convention event hours. Any service outage required to complete the work shall be the time and for the length of time as directed by the Owner. All premium time shall be included in Contractor's bid.

Fire Stops and Penetration Seals: All penetrations through fire rated floors and walls shall be sealed with 3M fire resistant foam sealant, to prevent the spread of smoke, fire, toxic gas or water through the penetration before, during or after a fire. The fire rating of the penetration seal shall be at least that of the floor or wall into which it is installed, so that the original fire rating of the floor or wall is maintained as required by Article 300.21 of the National Electrical Code.

Clean Up: Provide for isolation of work areas and daily removal of debris.

Submittal Data: Submittal are required but not limited to: Conduit/fittings; wires, transformers

Final Inspection & Operating Tests: All electrical systems must be checked for proper polarity and sequence, all motors must be checked for proper rotation and all equipment checked for proper voltage and phasing requirements. Prior to the

application of any power, the Contractor must certify that all connected equipment match the characteristics of the supply circuit voltage, phasing and feeder requirements.

After all systems have been completed and put into operation, subject each system to an operating test under design conditions to ensure proper sequence and operation throughout the range of operation, make adjustments as required to ensure proper functioning of all systems.

Warranty: Guarantee all work and materials furnished under this contract for a period of one year from the date of acceptance by the Owner. Guarantee shall include: All labor, parts, travel/subsistence, software changes/re-programming, etc.

Record Drawings: Maintain a continuous daily record during the course of construction of all changes and deviations in the work from the accompanying drawings. Show exact dimensions for all under-slab conduits. Upon completion of work, purchase a set of mylar reproducibles and make corrections as required to reflect the electrical systems as installed. Submit three prints of the tracings for approval. Make corrections to tracings as directed and deliver mylar tracings to the Owner.

New circuits: shall be 2 # 12 THWN, 1 #12 ground, 3/4" conduit to new 20 amp/1-pole breaker typical. New breakers installed in existing panels shall match existing in style, make and A.I.C. ratings. Use 10 AWG conductors for 20 ampere, 120 volt branch circuits longer than 75 feet. May use existing spare breakers if available.
Field verify availability of spaces/spares in existing panel(s). **Provide new sub-panel**(s) if spaces/spares are not available. Typical new sub-panel(s): 100 Amp M.L.O. 208Y/120 Volt, 3 phase, 4 wire with ground bus, 24 pole, with (24) 20A/1P breakers. Install 100A/3P breakers in existing panel to feed new sub-panel(s). Feeder shall be 4 # 1 THWN, 1 # 8 THWN ground, 1 1/2" conduit. Relocate any displaced circuits due to installation of feeder breaker to new sub-panel(s), provide conduit/wire extension as required. Sub-panel(s) may be mounted remotely if space is not available in vicinity of existing panel(s). Provide panelboard bonding. Loadcenter type panels are not acceptable.

Conduit
Conduit: Shall be rigid galvanized steel (RGS) or electrical metallic tubing (EMT) as manufactured by Allied, Triangle or Wheatland. Indoors above grade: EMT or RGS. Outdoors above grade, stub-ups, or on roof: RGS, IMC . Compression or set-screw type fittings shall may be used for EMT. Minimum conduit size 1/2 inch, however homerun to panel shall be minimum 3/4 inch.

Type "MC" metal clad cable is acceptable only for drops from ceiling junction boxes to receptacles boxes. MC homerun to panels is not acceptable. Type "AC" armored cable (commonly referred to as "BX") is not acceptable. Electrical nonmetallic tubing (ENT, N.E.C. Article 362) shall not be used. Flexible conduit shall be utilized as final connections (5' only) at vibration producing equipment. Utilize flexible metallic conduit and include a green ground wire. Use sealtite in wet locations.

Conduit shall be supported from structure every 5 feet and within 3 feet of all boxes. Use locknuts inside and out at boxes. Maintain minimum 12" separation from all high temperature pipes. All conduit runs shall be installed parallel or perpendicular to building lines. Route conduit as directly as possible with largest radius bends possible. Make bends with standard ells or bends per NEC. Provide expansions fittings if conduit crosses structural expansion joint. Clean conduit interior after installation; coat scratches with zinc paint. Provide pull wire in all conduit.

Building Wire and Cable
Wire: (Triangle, American Insulated Cable Co., or Cablec). All wiring shall be in conduit (except plenum rated low voltage cables). All wires must be 75-degree C rated or better, 60-degree C rated wire shall not be used. 90-degree C rated wire may be used but only at 75-degree C ampacity. Emergency and Normal circuits must be installed in separate conduit and device boxes per N.E.C. Article 700.9.(b).

Minimum size #12 except controls may be #14. Use #10 conductors for 20 ampere, 120 volt branch circuits longer than 100 feet. Type THHN/THWN stranded copper thermoplastic in dry locations. Type THWN in wet locations. All wire shall be 98% conductivity copper, 600 volt. NO ALUMINUM WIRES. Wire #10 and smaller may be solid or stranded, #8 or larger shall be stranded.

Field Insulation Testing: Insulation resistance of all conductors shall be tested. Each conductor shall have its insulation resistance tested after the installation is completed and all splices, taps and connections are made except connection to or into its source and point (or points) of termination. Insulation resistance of conductors which are to operate at 600 volts or less shall be tested by using a Biddle megger of not less than 1000 volts DC. Insulation resistance of conductors rated at 600 volts shall be free of shorts and grounds and have a minimum resistance phase-to-phase and phase-to-ground of

at least 10 megohms. Conductors that do not exceed insulation resistance values listed above shall be removed at Contractor's expense and replaced and test repeated. The Contractor shall furnish al instruments and personnel required for tests, shall tabulate readings observed, and shall forward copies of the test readings to the Owner. These tests reports shall identify each conductor tested, date and time of test and weather conditions. Each test shall be signed by the party making the test.

Boxes: Galvanized steel suitable for location. Provide Raco, Steel City or Appleton. ALL J-BOXES/SPLICE BOXES MUST BE ACCESSIBLE. Junction/Pull boxes: for each conduit run: provide one junction/pull box for each equivalent three quarter bends (270-degrees).

Wiring Devices: Furnish and install where required by controls contractor. Cover plates: aluminum or steel. Provide circuit number label on all device plates.

Testing and Certification: deliver a written report certifying that every new receptacle has been tested as follows and found acceptable: (a) The physical integrity of each receptacle shall be confirmed by visual inspection. (b) The continuity of the grounding circuit in each electrical receptacle shall be verified. (c) Correct polarity of the hot and neutral connections in each electrical receptacle shall be confirmed. (d) The retention force of the grounding blade of each electrical receptacle (except locking-type receptacles) shall be not less than 115 grams (4 oz.).

Grounding and Bonding: All conduit work and electrical equipment shall be effectively and permanently grounded in accordance with NEC requirements. Provide green equipment grounding conductor with all power and receptacle and lighting circuits. Green equipment grounding conductor shall be routed from panel ground bus to final devices.

Electrical Identification: Label all junction and pull boxes with panels and circuit numbers. Conduit: Match existing color coding banding or markers. Mark all branch conduits with circuit numbers at or near each panel location. Update panel directories where circuits are added or revised.

Dry Type Transformers: Provide dry type quiet transformers (per ANSI -C89 and UL 506), self-cooled NEMA Class AA. Copper wire windings. Aluminum-winding transformer is acceptable, provided it is in compliance with NEC clearance requirements. Transformers must meet or exceed NEMA TP-1 energy efficiency standards.