CALIFORNIA POLYTECHNIC STATE UNIVERSITY
FACILITIES PLANNING & CAPITAL PROJECTS
San Luis Obispo, CA 93407-0690
p 805/756-2581 f 805.756.7566
http://www.afd.calpoly.edu/facilities/

Yosemite Repipe Project
MAJ 13-MJ0053

ADDENDUM #01

PROJECT MANAGER:
Michael Brennan
Project Manager
Facilities Planning & Capital Projects
mgbrenna@calpoly.edu

ARCHITECT/ENGINEER:
Goss Engineering, Inc.
320 S. Main Street
Corona, CA 92882
lbh@gossengineering.com

DATE: April 2, 2013

Submittal Date: **April 11, 2013 *before* 2:00 p.m.**

The following additions, deletions, and revisions to the Drawings and Project Manual are a part of the Contract Documents.

Each Bidder shall:
- ❑ Submit the information contained in this addendum to their subcontractors and suppliers.
- ❑ Acknowledge receipt of addenda on the Bid Form.

Note: Failure to acknowledge addenda in the space provided on the Bid Form may subject the Bidder to disqualification.

Item 1-1 Division 0, Section 00 01 05 Part A – Notice to Contractors

REPLACE BID DATE WITHIN THE FIRST TWO PARAGRAPHS OF THE NOTICE TO CONTRACTORS AS FOLLOWS:

The Trustees of The California State University will receive sealed bid proposals in the Facilities Training Room, Building 70, at the address above, **before 2:00 p.m., on ~~Tuesday, April 9, 2013~~ Thursday, April 11, 2013,** for furnishing all labor and materials for the construction of the **Yosemite Repipe Project, Project Number MAJ 13-MJ0053,** for the California Polytechnic State University, San Luis Obispo, campus.

Proposals will be received in the above-mentioned room **until 2:00 p.m. on ~~Tuesday, April 9, 2013~~ Thursday, April 11, 2013,** in accordance with the contract documents, at which time proposals will be publicly opened and read.

Refer to attached Notice to Contractors (**ADD #01a**).

Item 1-2 Division 0, 00 01 05 Part A – Sample Bid Proposal Form

REPLACE BID DATE ON THE LAST PAGE OF THE SAMPLE BID PROPOSAL FORM, FOURTH PARAGRAPH FROM BOTTOM OF LAST PAGE AS FOLLOWS:

The bid must be submitted on this Proposal Form, completely filled out and in a sealed envelope provided by the Trustees, and delivered to Facilities Planning & Capital Projects, Building 70, Room 114 at California Polytechnic State University, San Luis Obispo, **before 2:00 p.m., on ~~Tuesday, April 9, 2013~~ Thursday, April 11, 2013,** or it will be disregarded. Only bids from prequalified contractors with a current **B (General Building)** license will be accepted.

Refer to attached Sample Bid Proposal Form (**ADD #01b**).

Item 1-3 Division 5, Section 05 120 Structural Steel, Part 2.02-B.

DELETE PART 2.02-B.:

~~B. Unfinished Threaded Fasteners: ASTM A307, Grade A, regular low carbon bolts and nuts.~~

Item 1-4 Division 22, Section 22 0500 Common Work Results for Plumbing

REPLACE IN ITS ENTIRETY:

Refer to attached Division 22, Section 22 0500 Common Work Results for Plumbing.
Updated Section 22 0500 2.5 C.

Item 1-5 Division 23, Section 23 0900 Instrumentation and Controls

REPLACE IN ITS ENTIRETY:

Refer to attached Division 23, Section 23 0900 Instrumentation and Controls.
Updated Section 23 0900 3.6 U. and 3.7 E.

Item 1-6 Division 23, Section 23 2113 Hydronic Piping and Valves

REPLACE IN ITS ENTIRETY:

Refer to attached Division 23, Section 23 2113 Hydronic Piping and Valves.
Updated Section 23 2113 3.10 B.

Item 1-7 Division 23, Section 23 2500 HVAC Water Treatment

REPLACE IN ITS ENTIRETY:

Refer to attached Division 23, Section 23 2500 HVAC Water Treatment.
Updated Section 23 2500 1.2 G., 2.1 A., 2.4 B., and 3.3 C.

Item 1-8 Drawing SK-1 Reference Sheet M15

ADD IN ITS ENTIRETY:

Refer to attached Drawing SK-1 Reference Sheet M15.
Note revision clouds correcting arrows showing direction of water flow.

Item 1-9 Drawing SK-2 Reference Sheet M14

ADD IN ITS ENTIRETY:

Refer to attached Drawing SK-2 Reference Sheet M14.
Note revision clouds, location of three valves were changed to facilitate proper isolation zones, number of valves remains the same.

Item 1-10 Drawing SK-3 Reference Sheet M18

ADD IN ITS ENTIRETY:

Refer to attached Drawing SK-3 Reference Sheet M18.
Note revision cloud locating floor level network panel.

Item 1-11 Drawing SK-4 Reference Sheet M19

ADD IN ITS ENTIRETY:

Refer to attached Drawing SK-4 Reference Sheet M19.
Note revision cloud noting addition of 2" conduit from cogen room to data room in residence hall D.

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NOTICE TO CONTRACTORS
YOSEMITE REPIPE PROJECT,
PROJECT NO. MAJ 13-MJ0053
CALIFORNIA POLYTECHNIC STATE UNIVERSITY, SAN LUIS OBISPO
Facilities Planning & Capital Projects – Bldg. 70
San Luis Obispo, CA 93407

The Trustees of the California State University will receive sealed bid proposals in the Facilities Training Room, Building 70, at the above address, **before 2:00 p.m., on Thursday, April 11, 2013**, for furnishing all labor and materials for the construction of the **Yosemite Repipe Project, Project Number MAJ 13-MJ0053**, for the California Polytechnic State University, San Luis Obispo, campus.

Proposals will be received in the above-mentioned room **until 2:00 p.m. on Thursday, April 11, 2013**, in accordance with the contract documents, at which time the proposals will be publicly opened and read.

In general, the work consists of, but is not limited to, demolition of the existing cogeneration unit and steam distribution system in Sierra Madre, and provision and installation of a new HW distribution system and the conversion of the steam system in Yosemite to heating water, on the California Polytechnic State University campus in San Luis Obispo, California in accordance with the plans and specifications.

All work shall be in accordance with the plans and specifications prepared by Goss Engineering, Inc., 320 S. Main Street, Corona, CA 92882. Contact Lucas Hyman, President, at Ph. 951.340.1977, Fx. 951.340.1090. Plans and specifications may be seen at the office of the University and Plan Rooms. The budget and construction estimate for work of the Base Bid is **$2,887,000.00**.

Plans and specifications will be available on compact disc (CD) only at no cost to the contractor and are available on or before **March 19, 2013**. Paper copies are not available. Distribution of the plans and specifications on CD will be done by California Polytechnic State University, San Luis Obispo. To receive a CD of the construction documents, submit a written request: by e-mail: rodonnel@calpoly.edu, fax: 805.756.7566 and/or mail. Requests may also be mailed to: MAJ 13-MJ0053, Yosemite Repipe Project, Facilities Planning & Capital Projects, Building 70, California Polytechnic State University, San Luis Obispo, San Luis Obispo, CA 93407, Attention: Rory O'Donnell. Requests should include: project name, project number, firm name, mailing address, phone/fax numbers, contact name & email address.

Each bidder offering a proposal must comply with bidding provisions of Article 2.00 *et seq.* of the Contract General Conditions. The bidder should familiarize himself with all the provisions of the Contract General Conditions.

Bidders must be prequalified with the Trustees. Prequalification of Prospective Bidders, Form 703.11 can be downloaded from the internet at http://www.calstate.edu/cpdc/cm/forms/prequalification/pq_prequalification_of_prospective_bidders_703.11.pdf, or bidders may contact the person below to request forms: Teri Carr, Prequalification Coordinator, The California State University, Chancellor's Office; Capital Planning, Design & Construction; Construction Management, 401 Golden Shore, Long Beach, CA 90802-4210. Ph. 562.951.4114, Fx. 562.951.4921, e-mail tcarr@calstate.edu . **In order to prequalify with The California State University, the completed forms must be filed at least ten (10) business days prior to the date for opening bids and approved not less than one business day prior to the date set for opening bids.**

This project is a public works project and is subject to prevailing wage rate laws (see Contract General Conditions, Article 4.02-c). Bidders should familiarize themselves with all the provisions of the Contract General Conditions and Supplementary General Conditions, including prevailing wage rates.

A mandatory pre-bid walkthrough has been scheduled for **Thursday, April 4, 2013, at 9:00 a.m.** Interested bidders shall assemble in Facilities Services (Bldg. 70), room 114 on the campus. Parking on campus is by paid permit only. Obtain daily parking permit, campus map, and directions at the Grand Avenue Information Center.

Familiarity with the Site: Each bidder must be familiar with the site (Contract General Conditions Article 2.04 et seq.).

Plan Holders List: A list of all plan rooms and contractors who have received the plans and specifications is available at the Facilities Planning & Capital Projects website. The list is updated weekly. Click on 'Campus Projects,' then on 'Construction Projects Currently Bidding.' http://www.afd.calpoly.edu/facilities/project_currentbid.asp?pid=2

Small Business Preference: Preference will be granted to bidders properly approved as "Small Business" in accordance with Title 2, California Code of Regulations, Section 1896 et seq. and the application of the five percent small business bidding preference is also extended to any non-small business that commits to subcontracting at least 25% of its net bid price to California certified small businesses and/or microbusinesses (Contract General Conditions Article 2.11).

The Trustees require the successful bidder to achieve a minimum requirement of three percent (3%) DVBE participation in contracting construction projects as established in the bidding documents. Achieving the minimum requirement must occur prior to the bid opening.

In accordance with Government Code section 14838(f), and Military and Veterans Code sections 999.5(a) and 999.5(d), the Trustees are granting a bid incentive for bid evaluation purposes only to bidders that exceed the three percent DVBE participation requirement. The level of DVBE incentive will correlate to the level of participation; that is, the more DVBE participation proposed, the higher the incentive. The bid incentives are as follows:

DVBE Participation	Incentive
3.00% to 3.99%	None
4.00% to 4.99%	1%
5% or more	2%

The DVBE incentive may not exceed $100,000. When used in combination with the Small Business Preference, the cumulative adjustment amount shall not exceed $100,000. If the lowest responsive, responsible bid is a California certified small business, the only bidders eligible for the incentive will be California certified small businesses.

Bidders shall contact the Trustees' DVBE Coordinator at 805/756-5190. Bidders can find California certified DVBE's and additional DVBE information at the DGS's Small Business and DVBE Services webpage at: http://www.pd.dgs.ca.gov/smbus/default.htm.

Bonds: A bid security in an amount equal to at least 10% of the amount of the bid (see Article 2.06(c) of the Contract General Conditions) is required. Contractor must use Bid Bond Form supplied by the University without alteration. Payment and Performance Bonds in the amount of 100% of the awarded contract price will be required of the successful bidder.

It will be the responsibility of each bidder to obtain a bid proposal package in sufficient time to fulfill requirements therein. Bid proposal packages are obtainable only by contractors, licensed in the State of California with a **B (General Building)** license, and the bid packages must be requested in writing from the Trustees, located at California Polytechnic State University, San Luis Obispo, Facilities Planning & Capital Projects, San Luis Obispo, CA 93407; Attention: Rory O'Donnell, e-mail rodonnel@calpoly.edu, fax no. 805.756.7566, phone no. 805/756-5376.

Contract Time: The time period for completion of the overall project shall be 125 calendar days from the Work start date of May 1, 2013 and Work completion date of September 2, 2013 as stated in the Notice to Proceed.

Liquidated Damages: Each Tower shall be considered complete when a Certificate of Occupancy is issued by the California State Fire Marshal's Office. Each Tower not complete by September 2, 2013 shall be assessed a liquidated damage assessment of Fifteen Thousand Dollars ($15,000.00) per week for each week completion is delayed beyond the time prescribed for the project. The week starts on Sunday and ends on Saturday.

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BID PROPOSAL FORM

YOSEMITE REPIPE PROJECT,
PROJECT NUMBER MAJ 13-MJ0053
CALIFORNIA POLYTECHNIC STATE UNIVERSITY, SAN LUIS OBISPO
One Grand Avenue
San Luis Obispo, CA 93407

To the Trustees of the California State University, on behalf of the State of California (hereinafter called the Trustees):

The undersigned bidder hereby offers, in the amount stated below, to furnish all labor, materials, tools, equipment, apparatus, facilities, transportation, and permits for the construction of Project Number **MAJ 13-MJ0053**, **Yosemite Repipe Project**, at California Polytechnic State University, San Luis Obispo, and hereby agrees to enter into contract for Project Number **MAJ 13-MJ0053** if this offer is accepted by the Trustees.

TOTAL AMOUNT OF BASE BID: $_____ LUMP SUM
(Use figures only)

The above Base Bid amount is to be stated in figures only and is the total amount bid for the entire contract work including all applicable taxes. Any alteration, erasure, or change must be clearly indicated and initialed by the bidder. The bidder agrees that if there are any discrepancies or questions in the figures, the Trustees will use the lower figure despite the bidder's intent. The Trustees reserve the right to reject any and all bids and to waive any irregularities. The architect's construction estimate (and the construction budget) for work of the Base Bid of this project is **$2,887,000.00**.

Award of the contract, if awarded, shall be based on the following: The lowest bid shall be determined as the lowest total of the bid prices of the Base Bid (PCC 10780.5(a)).

SPECIFY THE NUMBER OF EACH ADDENDUM YOU HAVE RECEIVED ON THE LINE BELOW
(WRITE THE NUMBER OF EACH AND EVERY ADDENDUM THAT YOU HAVE RECEIVED)

The bid is subject to the provisions contained in the Contract General Conditions (note especially Article 2.00 *et seq.* regarding instructions to bidders), and the bidder agrees that failure to comply with the conditions thereof shall be basis for rejection of this bid.

The undersigned bidder is an approved **Small Business Contractor** and is hereby requesting the 5% Small Business Preference. Bidder has attached Small Business Preference and Certification Request. (Title 2, California Code of Regulations, Section 1896, *et seq*).

YES_____ NO_____

The undersigned bidder is a **Non-Small Business** and is hereby requesting the 5% Small Business Preference. Bidder has attached Small Business Preference and Certification Request *and* commits to subcontract at least 25% of its total bid price with one or more small business(es). (Title 2, California Code of Regulations, Section 1896, *et seq*).

YES_____ NO_____

The Trustees require the successful bidder to achieve a minimum requirement of three percent (3%) DVBE participation in contracting construction projects as established in the bidding documents, and this must occur prior to bid opening.

In accordance with Government Code section 14838(f), and Military and Veterans Code sections 999.5(a) and 999.5(d), the Trustees are granting a bid incentive for bid evaluation purposes only to bidders that exceed the three percent DVBE participation requirement. The level of DVBE incentive will correlate to the level of participation; that is, the more DVBE participation proposed, the higher the incentive. The bid incentives are as follows:

DVBE Participation	Incentive
3.00% to 3.99%	None
4.00% to 4.99%	1%
5% or more	2%

The DVBE incentive may not exceed $100,000. When used in combination with the Small Business Preference, the cumulative adjustment amount shall not exceed $100,000. If the lowest responsive, responsible bid is a California certified small business, the only bidders eligible for the incentive will be California certified small businesses.

The undersigned bidder is hereby requesting the **DVBE Bid Incentive** for exceeding the 3% DVBE participation requirement. Bidder commits to subcontract at least the percentage of DVBE Participation of the total bid price under the Contract as stated below with one or more DVBE(s). (Government Code section 14838(f), and Military and Veterans Code sections 999.5(a) and 999.5(d)).

YES_____ NO_____

DVBE Participation Percentage Commitment_____

DVBE Participation	Incentive
3.00% to 3.99%	None
4.00% to 4.99%	1%
5% or more	2%

The bid must be submitted on this Proposal Form, completely filled out and in a sealed envelope provided by the Trustees, and delivered to Facilities Planning & Capital Projects, Building 70, Room 114 at California Polytechnic State University, San Luis Obispo, **before 2:00 p.m. on Thursday, April 11, 2013**, or it will be disregarded. Only bids from prequalified contractors with a current **B (General Building)** license will be accepted.

Bidder shall enclose with this Proposal Form bidder's security in the amount equal to at least ten (10) percent of the amount of bid (see Contract General Conditions, Article 2.06(c)). If the bidder is awarded the contract and then fails to execute the contract, this bidder's security shall be forfeited to the State.

The time period for completion of the overall project shall be 125 calendar days from the Work start date of May 1, 2013 and Work completion date of September 2, 2013 as stated in the Notice to Proceed.

Liquidated Damages: Each Tower shall be considered complete when a Certificate of Occupancy is issued by the California State Fire Marshal's Office. Each Tower not complete by September 2, 2013 shall be assessed a liquidated damage assessment of Fifteen Thousand Dollars ($15,000.00) per week for each week completion is delayed beyond the time prescribed for the project. The week starts on Sunday and ends on Saturday.

SECTION 22 0500

COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
6. Escutcheons.
7. Grout.
8. Equipment installation requirements common to equipment sections.
9. Painting and finishing.
10. Supports and anchorages.

1.2 DEFINITIONS

A. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

B. The following are industry abbreviations for plastic materials:

1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. CPVC: Chlorinated polyvinyl chloride plastic.
3. PE: Polyethylene plastic.
4. PVC: Polyvinyl chloride plastic.

C. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-dieneterpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.3 SUBMITTALS

A. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

B. Welding certificates.

1.4 QUALITY ASSURANCE

A. Groove-less clamps, cut groove pipe and fittings, reducing couplings, mechanical tees or saddle fittings are not acceptable for use on campus.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

1.6 COORDINATION

A. Coordinate with other sections of the specifications for the applicability of materials specified in this section. Not every product or material listed may be used.

B. Coordinate requirements of this section with actual work to be performed. This section is general in scope for basic materials and methods, all of which may not actually apply to this project.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

1. Or Equal: Where products are specified by manufacturers name and accompanied by the term "or equal", comply with provisions in Division 01 Section “Product Requirements”, Part 2 “Product Substitutions” Article. Specific procedures must be followed before use of an unnamed product or manufacturer.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 22 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: Bolts shall be United States Customary System bolts and nuts (e.g. ¾"). Metric bolts and nuts shall not be used. Bolts and nuts shall be SAE Grade 5 hot-dip galvanized steel or stainless steel with heavy hex nuts.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series, BCup3 or BCUp4, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

1. Manufacturers:

a. Cascade Waterworks Mfg. Co.
b. Dresser Industries, Inc.; DMD Div.
c. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
d. JCM Industries.
e. Smith-Blair, Inc.
f. Viking Johnson.
g. Or equal.

2. Aboveground Pressure Piping: Pipe fitting.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated for 150 – or 300-psig minimum working pressure, suitable for system fluid, pressure, and temperature.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

1. Manufacturers:

a. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Epco Sales, Inc.
d. Watts Industries, Inc.; Water Products Div.
e. Or equal.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Manufacturers:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.
e. Or equal.

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

1. Manufacturers:

a. Calpico, Inc.
b. Lochinvar Corp.
c. Or equal.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

1. Manufacturers:

a. Perfection Corp.
b. Precision Plumbing Products, Inc.
c. Sioux Chief Manufacturing Co., Inc.
d. Victaulic Co. of America.
e. Or equal.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction

loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping to permit valve servicing.

E. Install piping at indicated slopes.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Verify final equipment locations for roughing-in.

K. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

L. Install valves in readily accessible locations, avoiding hard-lid ceilings where possible. Provide access panels for valve access complying with Division 08, and coordinate access panel locations with other disciplines.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Oxyacetylene torch welding and cutting of structural steel or bolt holes shall not be permissible.

F. Install main and branch piping using specified fittings, “T-drill”, “welded nozzles”, or “Side-Tap” or similar fitting substitution style connections are not acceptable.

G. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

H. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

I. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

J. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install shut-off valves at final connection to each piece of equipment.
2. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
3. Install flanges, in piping NPS 2-1/2and larger, adjacent to flanged valves and at final connection to each piece of equipment.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.5 PAINTING

A. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psiCast-in-Place Concrete

3.7 GROUTING

A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 22 0500

SECTION 23 0900

INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 WORK INCLUDED:

A. GENERAL - Building Management System (BMS) Contractor shall provide and install:

1. A fully integrated Building Automation System (BAS), incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified.
2. Complete temperature control system to be DDC with electric actuation as specified herein.
3. All wiring, conduit, panels, and accessories for a complete operational system.
4. BMS Contractor shall be responsible for all electrical work associated with the BMS. Power to control panels is by Div 26 contractor.

    a. Perform all wiring in accordance with all local and national codes.
    b. Install all line voltage wiring, concealed or exposed, in conduit in accordance with the division 26 specifications, NEC and local building code.
    c. Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Controllers and operator's workstations.
    d. All low voltage electrical control wiring throughout the building when exposed or in an un-accessible location shall be run in conduit in accordance with the division 26 specifications, local building code and the NEC. Low voltage wiring throughout the building, when in concealed accessible locations, can be run using plenum rated wire and supported from duct work or ceiling supports.

5. All wells for water monitoring devices, flow switches and alarms, as required.
6. Provide open communications system. The system shall be an open architecture with the capabilities to support a multi-vendor environment. To accomplish this effectively, system shall be capable of utilizing standard protocols as follows as well as be able to integrate third-party systems via existing vendor protocols.

    a. System shall be capable of high speed Ethernet communication using TCP/IP protocol.
    b. System shall be capable of BACnet communication according to ANSI/ASHRAE 135-2004.
    c. System shall be capable of OPC server communications according to OPC Data Access 2.0 and Alarms and Events 1.0..
    d. The system shall be capable of supporting both standard and vendor specific protocols to integrate a wide variety of third-party devices and legacy systems.
    e. The system shall be capable of supporting wireless field level networks and sensor communications using a mesh topology and IEEE 802.15.4 network.
    f. The intent is to either use the Operator Workstation provided under this contract to communicate with control systems provided by other vendors or to allow information about the system provided in this contract to be sent to another

workstation. This allows the user to have a single seat from which to perform daily operation.

7. Provide system graphics for each controlled device and/or integrated systems as required by the owner. Origin of information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the BMS.

B. General Product Description

1. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation, or identification number and sequence of operation all bearing the name of the manufacturer. The installing manufacturer shall certify in writing, that the shop drawings have been prepared by the equipment manufacturer and that the equipment manufacturer has supervised their installation. In addition, the equipment manufacturer shall certify, in writing, that the shop drawings were prepared by their company and that all temperature control equipment was installed under their direct supervision.
2. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project.
3. The system shall be scalable in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, and operator devices.
4. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Controller shall operate independently by performing its own specified control, alarm management, operator I/O, and data collection. The failure of any single component or network connection shall not interrupt the execution of any control strategy, reporting, alarming and trending function, or any function at any operator interface device.
5. DDC Controllers shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC Controllers shall also be able to send alarm to multiple operator workstations without dependence upon a central or intermediate processing device.
6. DDC Controllers shall be able to assign password access and control priorities to each point individually. The Iogon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust or control only the points that the operator is authorized for. All other points shall not be displayed at the PC workstation or portable terminal. (e.g. all base building and all tenant points shall be accessible to any base building operators, but only certain base building and tenant points shall be accessible to tenant building operators). Passwords and priority levels for every point shall be fully programmable and adjustable.

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Hydronic Piping:

1. Control Valves
2. Temperature Sensor Wells and Sockets
3. Flow Switches
4. Flow Meters

1.3 Not Used

1.4 PRODUCTS INTEGRATED TO BUT NOT FURNISHED OR INSTALLED UNDER THIS SECTION

A. Variable Frequency Drives:

B. BACnet System

1. Server
2. Client

1.5 RELATED SECTIONS

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.

B. The following sections constitute related work:

1. Section 23 0500 – Common Work Results for HVAC
2. Section 23 0593 - Testing, Adjusting, and Balancing for HVAC
3. Section 26 0500 - Common Work Results for Electrical

1.6 APPROVED CONTROL SYSTEM CONTRACTORS AND MANAGERS

A. The following are the approved Control System Contractors and Manufacturers:

1. Siemens Industry, Inc. – Product Line: APOGEE System.
2. System must match existing using campus standards as dictated by this specification. Gateway, integrator, or “blackbox” communications interfaces are not acceptable. All functionality of the System 600 Apogee shall be provided at any new and existing workstations including but not limited to: trending, archiving, custom reporting, system profiler, programming scheduling etc.
3. Acceptable direct factory branch: 10775 Business Center Drive. Cypress, CA 90630 (714) 816-1435 – Mary Johnson.

1.7 QUALITY ASSURANCE

A. The BAS system shall be designed and installed, commissioned and serviced by factory trained personnel. BMS contractor shall have an in-place support facility within 60 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment. The B.M.S. contractor shall provide full time, experienced project manager for this work, responsible for direct supervision of the design, installation, start up and commissioning of the B.M.S. The PM should be available by cell phone during normal working hours and on-site when directed for related meetings and coordination. The bidder shall be regularly engaged in the installation and maintenance of BMS systems and shall have a minimum of twenty (20) years of demonstrated technical expertise and experience in the installation and maintenance of

B.M.S. systems similar in size and complexity to this project in the greater Los Angeles/Southern California area.

B. The BMS contractor shall maintain an established service organization consisting of factory trained service personnel and provide a list of 10 projects, similar in size and scope to this project, completed within the last five years.

C. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

D. All BAS peer-to-peer network controllers, central system controllers, and local user displays shall be UL Listed under Standard UL 916, category PAZX; Standard ULC C100, category UUKL7; and under Standard UL 864, categories UUKL, UDTZ, and QVAX and be so listed at the time of bid. All floor level controllers shall comply, at a minimum, with UL Standard UL 91 6category PAZX; Standard UL 864, categories UDTZ, and QVAX and be so listed at the time of Bid.

E. The BAS peer-to-peer network controllers and local user display shall also comply with the European Electromagnetic Compatibility (EMC) Framework, and bear the C-Tic Mark to show compliance. The purpose of the regulation is to minimize electromagnetic interference between electronic products, which may diminish the performance of electrical products or disrupt essential communications.

F. DDC peer-to-peer controllers shall be compliant with the European EMC Directive, Standards EN 50081-2 and EN 50082-2, at the Industrial Levels. Additionally the equipment shall be compliant with the European LVD Directive and bear the CE mark in order to show compliance to both directives.

G. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

H. All wireless devices, if used, shall conform to:

1. The requirements of Title 47 of the Code of Federal Regulations, FCC Part 15, governing radio frequency intentional radiating devices and be issued a FCC user identification and be so labeled.

I. The manufacturer of the building automation system shall provide documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing) and ISO-140001 (The application of well-accepted business management principles to the environment). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.

J. This system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing field panels to current level of technology, and extend new field panels on a previously installed network. Compatibility shall be defined as the ability for any existing field panel microprocessor to be connected and directly communicate with new field panels without bridges, routers or protocol converters.

1.8 CODES AND STANDARDS

A. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with current editions in effect 30 days prior to receipt of bids of the following codes:

1. National Electric Code (NEC)
2. Uniform Building Code (UBC)

    a. Section 710.5, Wiring in Plenums
    b. Section 1106, Refrigeration Machinery Rooms
    c. Section 1107, Refrigeration Machinery Room Ventilation
    d. Section 1108, Refrigeration Machinery Room Equipment and Controls

3. Uniform Mechanical Code (UMC)
4. ANSI/ASHRAE Standard 135- 2004, BACnet--A Data Communication Protocol for Building Automation and Control Networks
5. [Local] Building Code

1.9 SYSTEM PERFORMANCE

A. Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).

1. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
2. Performance. Programmable controllers shall be able to completely execute DDC control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control

1.10 SUBMITTALS

A. Product Submittal Requirements. Meet requirements of Section 01330 on Shop Drawings, Product Data, and Samples. Provide six copies of shop drawings and other submittals on hardware, software, and equipment to be installed or furnished. Begin no work until submittals have been approved for conformity with design intent. Provide drawings as AutoCAD 2004 (or newer) compatible files on optical disk (file format: .dwg, .dxf, .vsd, or comparable) or hard copies on 11" x 17" prints of each drawing. When manufacturer's cutsheets apply to a product series rather than a specific product, clearly indicate applicable data by highlighting or by other means. Clearly reference covered specification and drawing on each submittal. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work.

B. Provide submittals within 8 weeks of contract award.

C. Submittal data shall consist of the following:

1. Direct Digital Control System Hardware:

    a. Complete bill of materials indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
    b. Manufacturer's description and technical data, such as product specification sheets, installation and maintenance instructions for items listed below and for relevant items not listed below:

        1) Direct Digital Controllers (controller panels)
        2) Transducers and transmitters
        3) Sensors (including accuracy data)
        4) Valves
        5) Dampers
        6) Relays and Switches
        7) Control Panels
        8) Power Supplies
        9) Operator Interface Equipment

    c. Wiring diagrams and layouts for each control panel. Show all termination numbers.
    d. Floor plan schematic diagrams indicating control panel and space temperature sensor locations.

2. Central System Hardware and Software:

    a. Complete bill of material indicating quantity, manufacturer, model number, and relevant technical data of equipment used.
    b. Manufacturer's description and technical data such as product specifications for items listed below and for relevant items furnished under this contract not listed below:

        1) Central Processing Unit (CPU)
        2) Monitors
        3) Keyboards
        4) Power Supply
        5) Battery Backup
        6) Interface Equipment Between CPU and Control Panels
        7) Operating System Software
        8) Operator Interface Software
        9) Color Graphic Software
        10) Third-Party Software

    c. Schematic diagrams of all control, communication, and power wiring for central system installation. Show interface wiring to control system.
    d. Provide a list of BMS point naming convention. Indicate the format, structure and standards of typical point names. The naming convention shall follow the "Global_Campus_Building_Area_Equipment_Function" format. Provide a list of point names for typical equipment and functions with specific examples.

3. Controlled Systems:

a. Riser diagrams showing control network layout, communication protocol, and wire types.
b. Schematic diagram of each controlled system. Label control points with point names. Graphically show locations of control elements.
c. Schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic use the same name.
d. Instrumentation list for each controlled system. List control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
e. Complete description of control system operation including sequences of operation. Include and reference schematic diagram of controlled system.
f. Point list for each system controller including both inputs and outputs (I/O), point numbers, controlled device associated with each I/O point, and location of I/O device.

4. Description of process, report formats and checklists to be used in Part 3: "Control System Demonstration and Acceptance."
5. Contractor shall submit documentation in the following phased delivery schedule:

a. Valve and damper schedules
b. Point Naming Convention
c. Sample Graphics
d. System schematics, including:

1) System Riser Diagrams
2) Sequence of Operations
3) Mechanical Control Schematics
4) Electrical Wiring Diagrams
5) Control Panel Layouts
6) Product Specification Sheets

e. As-Built drawings

D. Project Record Documents: Submit three copies of record (as-built) documents upon completion of installation. Submittal shall consist of:

1. Project Record Drawings. As-built versions of the submittal shop drawings provided as AutoCAD 2010 (or newer) compatible files on optical media and as 11" x 17" prints.
2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements of Part 3: "Control System Demonstration and Acceptance."
3. Operation and Maintenance (O & M) Manual.

a. As-built versions of the submittal product data.
b. Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.
c. Operator's Manual with procedures for operating control systems, logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.

d. Programming manual or set of manuals with description of programming language and of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
e. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
f. Documentation of all programs created using custom programming language, including set points, tuning parameters, and object database.
g. Graphic files, programs, and database on magnetic or optical media.
h. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware, including computer equipment and sensors.
i. Complete original original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
j. Licenses, guarantees, and warranty documents for equipment and systems.

E. Training Materials. Provide course outline and manuals at least six weeks before training.

1.11 WARRANTY

A. Warrant labor and materials for specified control system free from defects for a period of 12 months after final acceptance. Failures on control systems that include all computer equipment, transmission equipment and all sensors and control devices during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.

B. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.

PART 2 - PRODUCTS

2.1 MATERIALS:

A. All products used in this project installation shall be new and currently manufactured and shall have been applied in similar installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner or Owner's representative. Spare parts shall be available for at least five years after completion of this contract.

2.2 COMMUNICATION:

A. The design of the BMS shall support networking of operator workstations and Building Controllers. The network architecture shall consist of two levels, an Ethernet based primary network for all operator workstations, servers, and primary DDC controllers along with secondary Floor Level Networks (FLN) for terminal equipment application specific controllers. The Ethernet net work will use the campus backbone whenever possible. Contractor will coordinate with the campus IT personnel to locate and identify proper connections.

B. Access to system data shall not be restricted by the hardware configuration of the building management system. The hardware configuration of the BMS network shall be totally transparent to the user when accessing data or developing control programs.

C. Operator Workstation Communication:

1. All color graphic operator workstations shall reside on the Ethernet network and the consoles shall be set up in a client/server configuration.
2. The servers will act as the central database for system graphics and databases to provide consistency throughout all system workstations.
3. The network shall allow concurrent use of multiple BMS software site licenses.

D. Management Level Network Communication (MLN)

1. All PCs shall simultaneously direct connect to the Ethernet Management Level Network without the use of an interposing device.
2. Operator Workstation shall be capable of simultaneous direct connection and communication with BACnet/IP, OPC and TCP/IP corporate level networks without the use of interposing devices.
3. The Management Level Network shall not impose a maximum constraint on the number of operator workstations.
4. Any controller residing on the primary building level networks shall connect to Ethernet network without the use of a PC or a gateway with a hard drive.
5. Any PC on the Management Level Network shall have transparent communication with controllers on the building level networks connected via Ethernet.
6. Any break in Ethernet communication from the PC to the controllers on the building level networks shall result in a notification at the PC.
7. The standard client and server workstations on the Management Level Network shall reside on industry standard Ethernet utilizing standard TCP/IP, IEEE 802.3.
8. System software applications will run as a service to allow communication with Primary Network Controllers without the need for user log in. Closing the application or logging off shall not prevent the processing of alarms, network status, panel failures, and trend information.
9. Any break in Ethernet communication between the standard client and server workstations on the Management Level Network shall result in a notification at each workstation.
10. Access to the system database shall be available from any standard client workstation on the Management Level Network.

E. Primary Network - Panel to Panel Communication:

1. All Building Controllers shall directly reside on the primary BACnet/IP Ethernet network such that communications may be executed directly between Building Controllers, directly between server and Building Controllers on a peer-to-peer basis.
2. Systems that operate via polled response or other types of protocols that rely on a central processor, file server, or similar device to manage panel-to-panel or device-to-device communications shall not be acceptable.
3. All operator interfaces shall have the ability to access all point status and application report data or execute control functions for any and all other devices. Access to data shall be based upon logical identification of building equipment. No hardware or

software limits shall be imposed on the number of devices with global access to the network data.

a. The primary network shall use BACnet/IP over Ethernet. All devices must:
b. Auto-sense 10/100 Mbps networks.
c. Configured with a Fixed IP Address.
d. Resolve Name to IP Addresses for devices using a Domain Name Service (DNS) Server on the Ethernet network.
e. Allow MMI access to an individual Primary Network Controller using industry standard Telnet software to view and edit entire Primary Network.

4. The primary network shall provide the following minimum performance:

a. Provide high-speed data transfer rates for alarm reporting, report generation from multiple controllers and upload/download efficiency between network devices. System performance shall insure that an alarm occurring at any Building Controller is displayed at any PC workstations, all Building controllers, and other alarm printers within 15 seconds.
b. Message and alarm buffering to prevent information from being lost.
c. Error detection, correction, and re-transmission to guarantee data integrity.
d. Synchronization of real-time clocks between Building Controllers, including automatic daylight savings time corrections.
e. The primary network shall allow the Building Controllers to access any data from, or send control commands and alarm reports directly to, any other Building Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. Building Controllers shall send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device. The network shall also allow any Building controller to access, edit, modify, add, delete, back up, restore all system point database and all programs.
f. The primary network shall allow the Building Controllers to assign password access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the PC workstation or portable terminal. (e.g. all base building and all tenant points shall be accessible to any base building operators, but only certain base building and tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.
g. Devices containing custom programming must reside on the Primary Network

F. Secondary Network – Application Specific Controller Communication:

1. Communication over the secondary network can be the manufacturer's standard protocol
2. Communication over the secondary network must allow BACnet MS/TP protocol.
3. This level communication shall support a family of application specific controllers for terminal equipment.
4. The Application Specific Controllers shall communicate bi-directionally with the primary network through Building Controllers for transmission of global data.
5. A maximum of 30 terminal equipment controllers may be configured on individual secondary network trunks to insure adequate global data and alarm response times.

2.3 OPERATOR INTERFACE:

A. Operator Interface Software:

1. Basic Interface Description

a. Operator interface software shall minimize operator training through the use of user-friendly and interactive graphical applications, 30-character English language point identification, on-line help, and industry standard Windows application software. Interface software shall simultaneously communicate with and share data between Ethernet-connected building level networks.
b. Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device, with a "point and click" approach to menu selection and a “drag and drop” approach to inter-application navigation.
c. The navigation shall be user friendly by utilizing “forward & back” capability between screens and embedded hyperlinks to open graphics, documents, drawings, etc.
d. Selection of applications within the operator interface software shall be via a graphical toolbar menu – the application toolbar menu shall have the option to be located in a docked position on any of the four sides of the visible desktop space on the workstation display monitor, and the option to automatically hide itself from the visible monitor workspace when not being actively manipulated by the user.
e. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. BMS software shall run on a Windows XP, 2000, or comparable 32 bit operating system. System database parameters shall be stored within an object-oriented database. Standard Windows applications shall run simultaneously with the BMS software. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BMS alarms and monitoring information
f. The software shall provide, as a minimum, the following functionality:

1) Real-time graphical viewing and control of the BMS environment
2) Reporting
3) Scheduling and override of building operations
4) Collection and analysis of historical data
5) Point database editing, storage and downloading of controller databases.
6) Utility for combining points into logical Point Groups. The Point Groups shall then be manipulated in Graphics, trend graphs and reports in order to streamline the navigation and usability of the system.
7) Alarm reporting, routing, messaging, and acknowledgment
8) “Collapsible tree,” dynamic system architecture diagram application:
   a) Showing the real-time status and definition details of all workstations and devices on a management level network
   b) Showing the real-time status and definition details of all Building Controllers at the Primary Network.
   c) Showing the definition details of all application specific controllers
9) Definition and construction of dynamic color graphic displays.

10) Online, context-sensitive help, including an index, glossary of terms, and the capability to search help via keyword or phrase.
11) On-screen access to User Documentation, via online help or PDF-format electronic file.
12) Automatic database backup at the operator interface for database changes initiated at Building Controllers.
13) Display dynamic trend data graphical plot.

    a) Must be able to run multiple plots simultaneously
    b) Each plot must be capable of supporting 10 pts/plot minimum
    c) Must be able to command points directly off dynamic trend plot application.
    d) Must be able to plot both real-time and historical trend data

14) Program editing
15) Transfer trend data to 3rd party spreadsheet software

    a) Scheduling reports
    b) Operator Activity Log
    c) Open communications via OPC Server
    d) Open communications via BACnet Client & Server

g. Enhanced Functionality:

1) Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via adjustable user-sized windows. Operator shall be able to drag and drop information between the following applications, reducing the number of steps to perform a desired function (e.g., Click on a point on the alarm screen and drag it to the dynamic trend graph application to initiate a dynamic trend on the desired point):

    a) Dynamic color graphics application
    b) Alarm management application
    c) Scheduling application
    d) Dynamic trend graph data plotter application
    e) Dynamic system architecture diagram application
    f) Control Program and Point database editing applications
    g) Reporting applications

2) Report and alarm printing shall be accomplished via Windows Print Manager, allowing use of network printers.

h. Security: Operator-specific password access protection shall be provided to allow the administrator/manager to limit users' workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow" the operator to any workstation logged onto (up to 999 user accounts shall be supported). The administrator or manager shall be able to grant discrete levels of access and privileges, per user, for each point, graphic, report, schedule, and BMS workstation

application. And each BMS workstation user account shall use a Windows Operating System user account as a foundation.

i. The operator interface software shall also include an application to track the actions of each individual operator, such as alarm acknowledgement, point commanding, schedule overriding, database editing, and logon/logoff. The application shall list each of the actions in a tabular format, and shall have sorting capabilities based on parameters such as ascending or descending time of the action, or name of the object on which the action was performed. The application shall also allow querying based on object name, operator, action, or time range.

j. Dynamic Color Graphics application shall include the following:

1) Must include graphic editing and modifying capabilities
2) A library of standard control application graphics and symbols must be included
3) Must be able to command points directly off graphics application
4) Graphic display shall include the ability to depict real-time point values dynamically with animation, picture/frame control, symbol association, or dynamic informational text-blocks
5) Navigation through various graphic screens shall be optionally achieved through a hierarchical "tree" structure
6) Graphics viewing shall include zoom capabilities
7) Graphics shall be capable of displaying the status of points that have been overridden by a field HAND switch, for points that have been designed to provide a field HAND override capability.
8) Advanced linking within the Graphics application shall provide the ability to navigate to outside documents (e.g., .doc, .pdf, .xls, etc.), Internet web addresses, e-mail, external programs, and other workstation applications, directly from the Graphics application window with a mouse-click on a customizable link symbol.

k. Reports shall be generated on demand or via pre-defined schedule, and directed to CRT displays, printers or file. As a minimum, the system shall allow the user to easily obtain the following types of reports:

1) A general listing of all or selected points in the network
2) List of all points currently in alarm
3) List of all points currently in override status
4) List of all disabled points
5) List of all points currently locked out
6) List of user accounts and access levels
7) List all weekly schedules and events
8) List of holiday programming
9) List of control limits and deadbands
10) Custom reports from 3rd party software
11) System diagnostic reports including, list of Building panels on line and communicating, status of all Building terminal unit device points
12) List of programs
13) List of point definitions
14) List of logical point groups
15) List of alarm strategy definitions
16) List of Building Control panels

17) Point totalization report
18) Point Trend data listings
19) Initial Values report
20) User activity report

l. Scheduling and override

1) Provide a calendar type format for simplification of time and date scheduling and overrides of building operations. Schedule definitions reside in the PC workstation and in the Building Controller to ensure time equipment scheduling when PC is off-line, PC is not required to execute time scheduling. Provide override access through menu selection, graphical mouse action or function key. Provide the following capabilities as a minimum:

a) Weekly schedules
b) Zone schedules
c) Event schedules – an event consists of logical combinations of equipment and/or zones
d) Report schedules
e) Ability to schedule for a minimum of up to ten (10) years in advance.

2) Additionally, the scheduling application shall:

a) Provide filtering capabilities of schedules, based on name, time, frequency, and schedule type (event, zone, report)
b) Provide sorting capabilities of schedules, based on name, time and type of schedule (zone, event, report)
c) Provide searching capabilities of schedules based on name – with wildcarding options

m. Collection and Analysis of Historical Data

1) Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals (up to four time-based definitions per point) or change of value, both of which shall be user-definable. Trend data shall be collected stored on hard disk for future diagnostics and reporting. Automatic Trend collection may be scheduled at regular intervals through the same scheduling interface as used for scheduling of zones, events, and reports. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.
2) Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of selected points. Provide additional functionality to allow predefined groups of up to 250 trended points to be easily transferred on-line to Microsoft Excel. BMS contractor shall provide custom designed spreadsheet reports for use by the owner to track energy usage and cost, equipment run times, equipment efficiency, and/or building environmental conditions. BMS contractor shall provide setup of custom reports including creation of data format templates for monthly or weekly reports.

3) Provide additional functionality that allows the user to view real-time trend data on trend graphical plot displays. A minimum of ten points may be plotted, of either real-time or historical data. The dynamic graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the display and take "snapshots" of plot screens to be stored on the workstation disk for future recall and analysis. Exact point values may be viewed and the graphs may be printed. A minimum of ten (10) dynamic graphs shall run simultaneously. Operator shall be able to command points directly on the trend plot by double clicking on the point. Operator shall be able to zoom in on a specific time range within a plot. The dynamic trend plotting application shall support the following types of graphs, with option to graph in 3D: line graph, area graph, curve graph, area-curve graph, step graph, and scatter graph. Each graph may be customized by the user, for graph type, graph text, titles, line styles and weight, colors, and configurable x- and y-axes.

n. Dynamic Color Graphic Displays

1) Capability to create color graphic floor plan displays and system schematics for each piece of mechanical equipment, including, but not limited to, Cogen units, Hydronic pumps, and Heat Exchangers.
2) The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, point alarm association, or text-based commands. Graphics software shall permit the importing of Autocad or scanned pictures for use in the system.
3) Dynamic temperature values, flow values and status indication shall be shown in their actual respective locations within the system schematics or graphic floor plan displays, and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.

a) Provide the user the ability to display real-time point values by animated motion or custom picture control visual representation. Animation shall depict movement of mechanical equipment, or air or fluid flow. Picture Control shall depict various positions in relation to assigned point values or ranges. A library (set) of animation and picture control symbols shall be included within the operator interface software’s graphics application. Animation shall reflect, ON or OFF conditions, and shall also be optionally configurable for up to five rates of animation speed.
b) Sizable analog bars shall be available for monitor and control of analog values; high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to "click and drag" the pointer to change the setpoint.
c) Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.

d) Equipment state or values can be changed by clicking on the associated point block or graphic symbol and selecting the new state (on/off) or setpoint.
e) State text for digital points can be user-defined up to eight characters.

4) Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.
5) Advanced linking within the Graphics application shall provide the ability to navigate to outside documents (e.g., .doc, .pdf, .xls, etc.), Internet web addresses, e-mail, external programs, and other workstation applications, directly from the Graphics application window with a mouse-click on a customizable link symbol.
6) The Windows environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
7) Off the shelf graphic software shall be provided to allow the user to add, modify or delete system graphic background displays.
8) A clipart library of HVAC application and automation symbols shall be provided including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams and laboratory symbols. The user shall have the ability to add custom symbols to the clipart library. The clipart library shall include a minimum of 400 application symbols. In addition, a library consisting of a minimum of 700 graphic background templates shall be provided.
9) The Graphics application shall include a set of standard Terminal Equipment controller application-specific background graphic templates. Templates shall provide the automatic display of a selected Terminal Equipment controller's control values and parameters, without the need to create separate and individual graphic files for each controller.

o. System Configuration & Definition

1) A "Collapsible tree," dynamic system architecture diagram/display application of the site-specific BMS architecture showing status of controllers, PC workstations and networks shall be provided. This application shall include the ability to add and configure workstations, Building Controllers, as well as 3rd-party integrated components. Symbols/Icons representing the system architecture components shall be user-configurable and customizable, and a library of customized icons representing 3rd-party integration solutions shall be included. This application shall also include the functionality for real-time display, configuration and diagnostics connections to Building Controllers.
2) Network wide control strategies shall not be restricted to a single Building Controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.
3) Provide automatic backup and restore of all Building controller databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate Building Controller. Changes made at the user-interface of

Building Controllers shall be automatically uploaded to the workstation, ensuring system continuity.

4) System configuration, programming, editing, graphics generation shall be performed on-line.
5) Point database configuration shall be available to the user within a dedicated point database editor application included in the operator interface software. The editor shall allow the user to create, view existing, modify, copy, and delete points from the database.
6) The point editor shall have the capability to assign "informational text" to points as necessary to provide critical information about the equipment.
7) The point editor shall also allow the user to configure the alarm management strategy for each point. The editor shall provide the option for editing the point database in an online or offline mode with the Building Controllers.
8) The operator interface software shall also provide the capability to perform bulk modification of point definition attributes to a single or multiple user-selected points. This function shall allow the user to choose the properties to copy from a selected point to another point or set of points. The selectable attributes shall include, but are not limited to, Alarm management definitions and Trend definitions.
9) Control program configuration shall be available to the user within a dedicated control program editor application included in the operator interface software. The editor shall allow for creation, modification and deletion of control programs. The editor shall include a programming assistance feature that interactively guides the user through parameters required to generate a control program. The editor shall also include the ability to automatically compile the program to ensure its compatibility with the Building Controllers. The editor shall provide the option for editing the control programs in an online or offline mode, and also the ability to selectively enable or disable the live program execution within the Building Controllers.

p. Alarm Management

1) Alarm Routing shall allow the user to send alarm notification to selected printers or workstation location(s) based on time of day, alarm severity, or point type.
2) Alarm Notification shall be presented to each workstation in a tabular format application, and shall include the following information for each alarm point: name, value, alarm time & date, alarm status, priority, acknowledgement information, and alarm count. Each alarm point or priority shall have the ability to sound a discrete audible notification.
3) Alarm Display shall have the ability to list & sort the alarms based on alarm status, point name, ascending or descending alarm time.
4) Directly from the Alarm Display, the user shall have the ability to acknowledge, silence the alarm sound, print, or erase each alarm. The interface shall also have the option to inhibit the erasing of active acknowledged alarms, until they have returned to normal status. The user shall also have the ability to command, launch an associated graphic or trended graphical plot, or run a report on a selected alarm point directly on the Alarm Display.

5) Each alarm point shall have a direct link from the Alarm Display to further user-defined point informational data. The user shall have the ability to also associate real-time electronic annotations or notes to each alarm.
6) Alarm messages shall be customizable for each point, or each alarm priority level, to display detailed instructions to the user regarding actions to take in the event of an alarm. Alarm messages shall also have the optional ability to individually enunciate on the workstation display via a separate pop-up window, automatically being generated as the associated alarm condition occurs. The system shall have the ability to modify the priority text based on operator preference.
7) Alarm Display application shall allow workstation operators to send and receive real-time messages to each other, for purposes of coordinating Alarm and BMS system management.

2.4 BUILDING CONTROLLER SOFTWARE

A. General:

1. Furnish the following applications software to form a complete operating system for building and energy management as described in this specification.
2. The software programs specified in this Section shall be provided as an integral part of Building Controllers and shall not be dependent upon any higher level computer or another controller for execution.
3. All points, panels and programs shall be identified by a 30 character name. All points shall also be identified by a 16 character point descriptor. The same names shall be displayed at both Building Controller and the Operator Interface.
4. All digital points shall have a user defined two-state status indication with 8 characters minimum (e.g. Summer, Enabled, Disabled, Abnormal).
5. The Building Controller Software shall be capable of BACnet communications. The BACnet Building Controller (B-BC) shall have demonstrated interoperability during at least one BTL Interoperability Workshop and shall substantially conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135-2004, Annex L.
6. Building Controllers shall have the ability to perform energy management routines including but not limited to time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating / cooling interlock, supply temperature reset, priority load shedding, and power failure restart.
7. The Building Controllers shall have the ability to perform the following pre tested control algorithms:

    a. Two position control
    b. Proportional control
    c. Proportional plus integral control
    d. Proportional, integral, plus derivative control
    e. Automatic tuning of control loops
    f. Model-Free Adaptive Control

8. Each controller shall be provided with an interactive HELP function to assist operators using POTs and remote connected operators.
9. Building Controllers shall not be susceptible` to Microsoft Windows operating systems based viruses.

B. System Security

1. User access shall be secured using individual security passwords and user names.
2. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
3. User Log On / Log Off attempts shall be recorded.
4. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.
5. Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the field panel.

C. User Defined Control Applications:

1. Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
2. It shall be possible to use any system measured point data or status, any system calculated data, a result from any process, or any user-defined constant in any controller in the system.
3. Any process shall be able to issue commands to points in any and all other controllers in the system.
4. Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
5. Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.
6. Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task oriented information from the user manual.

D. Alarm Management:

1. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each Building Controller shall perform distributed, independent alarm analysis, minimize network traffic and prevent alarms from being lost. At no time shall the Building Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.
2. Conditional alarming shall allow generation of alarms based upon user defined multiple criteria.
3. An Alarm “shelving” feature shall be provided to disable alarms during testing. (Pull the Plug, etc.).
4. Binary Alarms. Each binary object shall be set to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.
5. Analog Alarms. Each analog object shall have both high and low alarm limits. Alarming must be able to be automatically and manually disabled.
6. All alarm or point change reports shall include the point's user defined language description and the time and date of occurrence.

7. Alarm reports and messages shall be routed to user-defined list of operator workstations, or other devices based on time and other conditions. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display graphics.
8. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response
9. Each Building Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assignable to any number of points in the Controller.

E. Scheduling:

1. Provide a comprehensive menu driven program to automatically start and stop designated multiple objects or events in the system according to a stored time.
2. Schedules shall reside in the building controller and shall not rely on external processing or network.
3. It shall be possible to define a group of objects as a custom event (i.e. meeting, athletic activity, etc.). Events can then be scheduled to operate all necessary equipment automatically.
4. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start and/or stop within that group.
5. The operator shall be able to define the following information:

    a. Time, day
    b. Commands such as on, off, auto, etc.
    c. Time delays between successive commands.
    d. There shall be provisions for manual overriding of each schedule by an authorized operator.

6. It shall be possible to schedule calendar-based events up to one year in advance based on the following:

    a. Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop, and night economizer. When a group of objects are scheduled together as an Event, provide the capability to adjust the start and stop times for each member.
    b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.

F. Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

G. Night setback control. The system shall provide the ability to automatically adjust setpoints for night control.

H. Loop Control. A Model-Free Adaptive Control algorithm or alternatively a PID (proportional-integral-derivative) closed-loop control algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to

position an output or stage a series of outputs. The controlled variable, set point, and weighting parameters shall be user-selectable.

I. Sequencing. Provide application software based upon the sequences of operation specified to properly sequence equipment.

J. Staggered Start:

1. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user definable.
2. Upon the resumption of power, each Building Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

K. Totalization:

1. Run-Time Totalization. Building Controllers shall automatically accumulate and store run-time hours for all digital input and output points. A high runtime alarm shall be assigned, if required, by the operator.
2. Consumption totalization. Building Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points.
3. Event totalization. Building Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for all points. The event totalization feature shall be able to store the records associated with events before reset.

L. Data Collection:

1. A variety of historical data collection utilities shall be provided to manually or automatically sample, store, and display system data for all points.
2. Building Controllers shall store point history data for selected analog and digital inputs and outputs:

    a. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each Building Controllers point group.

3. Trend data shall be stored at the Building Controllers and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either user-defined interval, manual command or when the trend buffers are full. All trend data shall be available for use in 3rd party personal computer applications.
4. Loop Tuning. Building Controllers shall also provide high resolution sampling capability for verification of DDC control loop performance. Documented evidence of tuned control loop performance shall be provided on a <monthly, seasonal, quarterly, annual> period.

    a. For Model-Free Adaptive Control loops, evidence of tuned control loop performance shall be provided via graphical plots or trended data logs. Graphical plots shall minimally include depictions of setpoint, process variable (output), and

control variable (e.g., temperature). Other parameters that may influence loop control shall also be included in the plot (e.g., fan on/off, mixed-air temp).

b. For PID control loops, operator-initiated automatic and manual loop tuning algorithms shall be provided for all operator-selected PID control loops. Evidence of tuned control loop performance shall be provided via graphical plots or trended data logs for all loops.
   1) In automatic mode, the controller shall perform a step response test with a minimum one-second resolution, evaluate the trend data, calculate the new PID gains and input these values into the selected LOOP statement.
   2) Loop tuning shall be capable of being initiated either locally at the Building Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

2.5 BUILDING CONTROLLERS

A. Building Controllers shall be 32 bit, multi-tasking, multi-user, real-time 48 MHz digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

B. Each Building Controller shall support a minimum of 3 directly connected Secondary Networks.

C. Each Building Controller shall have sufficient memory, a minimum of 72 megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, and dial-up communications.

D. Building Controller shall have an integral real-time clock.

E. Each Building Controller shall support firmware upgrades without the need to change hardware.

F. Each Building Controller shall support:

1. Monitoring of industry standard analog and digital inputs, without the addition of equipment outside the Building Controller cabinet.
2. Monitoring of industry standard analog and digital outputs, without the addition of equipment outside the Building Controller cabinet.

G. Serial Communication. Building Controllers shall provide at least two EIA-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, and portable laptop operator's terminals. Building Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected printers or terminals.

H. Manual Override. The operator shall have the ability to manually override automatic or centrally executed commands at the Building Controller via local, point discrete, integral hand/off/auto operator override switches for all digital control type points and gradual switches for all analog control type points. These override switches shall be operable whether the panel

processor is operational or not. Each Building Controller shall monitor and alarm the hand, off and auto positions of integral HOA switches. [off]

I. I/O Status and Indication. Building Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. All wiring connections shall be made to field-removable terminals.

J. Self Diagnostics. Each Building Controller shall continuously perform self diagnostics, communication diagnosis, and diagnosis of all panel components. The Building Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication for any system.

K. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 100 hours.

L. Environment.

1. Controller hardware shall be suitable for the anticipated ambient conditions.
2. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
3. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

M. Immunity to power and noise.

1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
3. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:

    a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3 V
    b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact
    c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power
    d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)

4. Isolation shall be provided at all Building Controller's AC input terminals to suppress induced voltage transients consistent with:

    a. IEEE Standard 587 1980
    b. UL 864 Supply Line Transients
    c. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

N. Minimum Approved Building Controllers. BMS Contractors shall furnish Building Controllers as listed below. Providing an approved controller does not release the contractor from meeting all performance, software and hardware specifications for Building Controllers and system operations.

1. Siemens Industry Inc. – PXC-Modular or PXC-Compact.

2.6 Not used

2.7 Input/Output Interface:

A. Hardwired inputs and outputs may tie into the system through building or application specific controllers.

B. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no damage to the controller.

C. Binary inputs shall allow the monitoring of On/Off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense “dry contact” closure without external power (other than that provided by the controller) being applied.

D. Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.

E. Analog inputs shall allow the monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with—and field configurable to— commonly available sensing devices.

F. Binary outputs shall provide for On/Off operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers shall have three-position (On/Off/Auto) override switches and status lights. Outputs shall be selectable for either normally open or normally closed operation.

G. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC, 4 to 20 mA or 0-20 PSI signal as required to provide proper control of the output device. Analog outputs on building or custom application controllers shall have status lights and a two-position (AUTO/MANUAL) switch and manually adjustable potentiometer for manual override. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.

H. Tri-State Outputs. Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices shall be limited to zone control and terminal unit control applications (VAV terminal units, duct-mounted heating coils, zone dampers, radiation, etc.). Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.

I. System Object Capacity. The system size shall be expandable to at least twice the number of input/ output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

2.8 POWER SUPPLIES AND LINE FILTERING

A. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

B. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand a 150% current overload for at least three seconds without trip-out or failure.

C. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.

D. Line voltage units shall be UL recognized and CSA approved.

E. Power line filtering.

1. Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component. Surge protection shall have the following at a minimum:

    a. Dielectric strength of 1000 volts minimum
    b. Response time of 10 nanoseconds or less
    c. Transverse mode noise attenuation of 65 dB or greater
    d. Common mode noise attenuation of 150 dB or better at 40 Hz to 100 Hz.

2.9 AUXILIARY CONTROL DEVICES

A. General

1. Specified in this section are the following hard wired input/output devices connected to the Building Controller or ASC.

    a. Ball Valves
    b. Automatic Control Valves
    c. Temperature Sensors
    d. Pressure Sensors
    e. Water Differential Pressure Sensors
    f. Water BTU Meters
    g. Relays
    h. Override Timers
    i. Current Transformers

j. Voltage Transmitters
k. Voltage Transformers
l. Power Monitors
m. Current Switches
n. Pressure Electric Switches
o. Electro-pneumatic Transducers
p. Local Control panels
q. Local User Display

B. Ball Valves.

1. Furnish automatic full port ball valves for isolation requirements on line sizes up to 2” as shown on the drawings or required herein. All ball valves shall have ANSI 250 body rating. Valves shall bronze body and stainless steel trim.
2. Valves shall close against a differential pressure equal to the design pump head pressure plus 10%.
3. The valves shall fail to their safe position upon power loss as specified in the sequence of operation.
4. All valves shall be provided with manual override.
5. Provide valve position indicator end switches with the actuator.
6. The valves shall be line size as shown on plans.
7. Motorized isolation valves shall be, Siemens, Dezurik or Neptronic.

C. Automatic Control Valves.

1. General:

a. Control valves shall be two-way single seated globe type for two-position or modulating service as shown. Valves shall meet ANSI Class IV leakage rating.
b. Body pressure rating and connection type construction shall conform to pipe, fitting and valve schedules. Where pressure and flow combinations exceed ratings for commercial valves and operators, industrial class valves and operators shall be provided.
c. Valve operators shall be of electric type.
d. The valves shall be quiet in operation and fail-safe in either normally open or normally closed position in the event of power failure.
e. Control valve operators shall be sized to close against a differential pressure equal to the design pump head plus 10 percent.
f. Furnish differential pressure control valves for all water systems as shown on plans and/or specified in the sequence of operations.
g. Provide valves 2" and smaller with screwed end bronze bodies and stainless steel trim. Provide valves 2-1/2" and larger with flanged ends, cast iron body and stainless steel trim.
h. For modulating service that require large valve size (above 4”), such as cooling tower temperature bypass, chiller head pressure ,etc. where proper control with globe type control valve cannot be achieved or the application is not economical butterfly or v-port ball valves are allowed.

2. Water Valves:

a. Control valves shall be of equal percentage flow characteristics for modulating service.

3. Aquastat:

   a. Strap-on type thermostats shall be provided for low or high temperature limit service on hot water or steam condensate pipes. The thermostats shall be UL listed, with a liquid-filled bulb type sensing element and capillary tubing. The thermostat shall operate within the 20°F to 120°F, or 100°F to 240°F, setpoint range, with an adjustable 6°F differential.
   b. The low-limit thermostat shall be automatic reset, snap acting SPDT type with concealed set point adjustment.

D. Temperature Sensors.

1. Provide Siemens 1000 Ohm Platinum RTD, Model Number PTM6.2P1K. Temperature sensors shall be connected to Campus Energy Management System (EMS) by Siemens.

2. Provide the following instrumentation as required by the monitoring, control and optimization functions. All temperature sensor shall use platinum RTD elements only, nickel or silicon are not acceptable. All control signals shall be via a 4-20 mA loop.

3. Liquid Immersion Temperature

a.	Temperature monitoring range	-40/+240 F
b.	Output signal	1000Ω RTD Resistance
c.	Installation adjustments	none required
d.	Element	Platinum
e.	Factory calibration point	32 deg F
f.	Accuracy at calibration point	+0.1% at 32F

4. Thermistor type temperature sensors will not be acceptable.

E. Water Differential Pressure Sensor

1. Provide Emerson Process Management Rosemount Model #1151 Pressure Transmitter per campus standards. Connect to campus Energy Management System (EMS) by Siemens. Specify pressure range for 150% of the maximum expected differential pressure.
2. Transducer shall have linear output signal. Zero and span shall be field adjustable.
3. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure up to 250 psig without damage.
4. Water pressure transducer shall have stainless steel diaphragm construction with elastomer seals. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and block and bleed valves..
5. Provide NEMA 4 construction differential pressure sensors for all differential pressure sensors and bypass valves. Sensor shall be factory calibrated for operating range and rated for system pressure. Provide manufacturers standard 3 valve manifold . Output shall be 4-20 ma. Sensor shall be Setra model 230 with 3 port manifold or approved equal.

F. Relays.

1. Control relays shall be UL listed plug-in type with dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage shall be suitable for application.

2. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable ±200% (minimum) from set point shown on plans. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.

G. Override Timers.

1. Override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration as required by application. Provide 0-to-6-hour calibrated dial unless otherwise specified. Timer shall be suitable for flush mounting on control panel face and located on local control panels or where shown.

H. Current Transmitters.

1. AC current transmitters shall be the self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4 to 20 mA two-wire output. Unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A full scale, with internal zero and span adjustment and ±1% full-scale accuracy at 500 ohm maximum burden.
2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA Recognized.
3. Unit shall be split-core type for clamp-on installation on existing wiring.

I. Current Transformers.

1. AC current transformers shall be UL/CSA Recognized and completely encased (except for terminals) in approved plastic material.
2. Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.
3. Transformers shall be fixed-core or split-core type for installation on new or existing wiring, respectively.

J. Voltage Transmitters.

1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4 to 20 mA output with zero and span adjustment.
2. 2 Ranges shall include 100 to 130 VAC, 200 to 250 VAC, 250 to 330 VAC, and 400 to 600 VAC full-scale, adjustable, with ±1% full-scale accuracy with 500 ohm maximum burden.
3. Transmitters shall be UL/CSA Recognized at 600 VAC rating and meet or exceed ANSI/ISA S50.1 requirements.

K. Voltage Transformers.

1. AC voltage transformers shall be UL/CSA Recognized, 600 VAC rated, complete with built-in fuse protection.
2. Transformers shall be suitable for ambient temperatures of 4°C to 55°C (40°F to 130°F) and shall provide ±0.5% accuracy at 24 VAC and a 5 VA load.
3. Windings (except for terminals) shall be completely enclosed with metal or plastic material.

L. Power Monitors.

1. Power monitors shall be the three-phase type furnished with three-phase disconnect/shorting switch assembly, UL Listed voltage transformers, and UL Listed split-core current transformers.
2. They shall provide a selectable rate pulse output for kWh reading and a 4 to 20 mA output for kW reading. They shall operate with 5 A current inputs with a maximum error of ±2% at 1.0 power factor or ±2.5% at 0.5 power factor.

M. Current Switches.

1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.

N. Pressure-Electric (PE) Switches

1. Shall be metal or neoprene diaphragm actuated, operating pressure rated 0-175 kPa (0-25 psig), with calibrated scale set point range of 14-125 kPa (2-18 psig) minimum, UL listed.
2. Provide one or two-stage switch action SPDT, DPST, or DPDT, as required by application. Electrically rated for pilot duty service (125 VA minimum) and/or for motor control.
3. Shall be open type (panel-mounted) or enclosed type for remote installation. Enclosed type shall be NEMA 1 unless otherwise specified.
4. Shall have a permanent indicating gauge on each pneumatic signal line to PE switches.

O. Local Control Panels.

1. All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable sub panels. A single key shall be common to all field panels and sub panels.
2. Interconnections between internal and face mounted devices shall be prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600 volt service, individually identified per control/ interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
3. Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

2.10 COMMUNICATION AND CONTROL WIRING

A. General:

1. Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of Division 16 unless otherwise noted herein.
2. All insulated wire to be copper conductors, UL labeled for 90°C minimum service.

B. Wire Sizing and Insulation

1. Wiring shall comply with minimum wire size and insulation based on services listed below:

	Service	Minimum Gage/Type	Insulation Class
a.	AC 24V Power	12 Ga Solid	600 Volt
b.	DC 24V Power	10 Ga Solid	600 Volt
c.	Class 1	14 Ga Stranded	600 Volt
d.	Class 2	18 Ga Stranded	300 Volt
e.	Class 3	18 Ga Stranded	300 Volt

2. Provide plenum-rated cable when open cable is permitted in supply or return air plenum where allowed per execution specifications defined in Paragraph 3.07

C. Control Wiring:

1. Digital Input/Output wiring shall use Class 2 twisted pair, insulated.
2. Analog inputs shall use Class 2 twisted shielded pair, insulated and jacketed and require a grounded shield.
3. Actuators with tri-state control shall use 3 conductor with same characteristics

D. Communication Wiring

1. Ethernet Cable shall be minimum CAT5
2. Secondary level network shall be 24 gage, TSP, low capacitance cable

E. Approved Cable Manufacturers:

1. Wiring from the following manufacturers which meet the above criteria shall be acceptable:

a. Anixter
b. Belden

PART 3 - EXECUTION

3.1 EXAMINATION:

A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/engineer for resolution before rough-in work is started.

B. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started.

3.2 PROTECTION:

A. The contractor shall protect all work and material from damage by its employees and/or subcontractors and shall be liable for all damage thus caused.

B. The contractor shall be responsible for its work and equipment until finally inspected, tested, and accepted.

3.3 COORDINATION:

A. Site

1. The project coordination between trades is the responsibility of the prime contractor who is the one tier higher contractual partner such as mechanical contractor, general contractor, construction manager, owner or owner's representative as applicable.
2. The controls contractor shall follow prime contractor's job schedule and coordinate all project related activities through the prime contractor except otherwise agreed or in minor job site issues. Reasonable judgment shall be applied.
3. Where the work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment.
4. If the contractor deviates from the job schedule and installs work without coordinating with other trades, so as to cause interference with work of other trades, the contractor shall make the necessary changes to correct the condition without extra charge.
5. Coordinate and schedule work with all other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.

B. Submittals.

1. Refer to the "Submittals" article in Part 1 of this specification for requirements.

C. Test and Balance

1. The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.

D. Not used

E. Coordination with controls specified in other sections or divisions.

1. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:

a. All communication media and equipment shall be provided as specified in Part 2, "Communication" of this specification.
b. Each supplier of controls product is responsible for the configuration, programming, startup, and testing of that product to meet the sequences of operation described in this section. This contractor will monitor and adjust their parameters only through the system specified here.
c. The Contractor shall coordinate and identify any incompatibility issues that arise between the control products provided under this section and those provided under other sections or divisions of this specification.
d. Each supplier of controls product is responsible for providing software database for properly configuring the communications to that system 8 weeks prior to

scheduled start-up. Contractor will notify all appropriate parallel contractors of this need.

e. The contractor is responsible for the interface of control products provided by multiple suppliers when the supplier has a BacNet or another acceptable open protocol device. Systems to be integrated will be shown on the drawings, points list, control details or sequence of operation.

3.4 GENERAL WORKMANSHIP:

A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Install all equipment in readily accessible locations as defined by Chapter 1, Article 100, Part A of the National Electrical Code (NEC).

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

1. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.5 FIELD QUALITY CONTROL:

A. Contractor shall have a quality manager on staff to inspect the project execution and to enforce quality standards.

B. All work, materials, and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this specification.

C. Contractor shall continually monitor the field installation for code compliance and quality of workmanship.

D. Contractor shall have work inspected by local and/or state authorities having jurisdiction over the work.

3.6 WIRING:

A. All control and interlock wiring shall comply with national and local electrical codes and Division 26 of this specification. Where the requirements of this section differ from those in Division 26, the requirements of this section shall take precedence.

B. All NEC Class 1 (line voltage) wiring shall be UL Listed in approved conduit according to NEC and Division 26 requirements.

C. All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be sub fused when required to meet Class 2 current limit.)

D. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in conduit may be used provided that cables are UL Listed for the intended application. For example, cables used in ceiling plenums shall be UL Listed specifically for that purpose.

E. All wiring in mechanical, electrical, or service rooms—or where subject to mechanical damage— shall be installed in EMT conduit.

F. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

G. Where plenum rated cable is run exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 3 m (10 ft) intervals.

H. Where plenum rated cable is used without conduit, it shall be supported from or anchored to structural members. Cables can be supported by or anchored to ductwork or ceiling suspension systems. Cables can not be supported by conduit or sprinkler piping.

I. All wire-to-device connections shall be made at a terminal block or wire nut. All wire-to-wire connections shall be at a terminal strip or wire nut.

J. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

K. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers or interposing relays.

L. All plenum rated wiring shall be installed as continuous lengths, with no splices permitted between termination points

M. All wiring in conduit shall be installed as continuous lengths, with no splices permitted between termination points or junction boxes.

N. Maintain fire rating at all penetrations. Install plenum wiring in sleeves where it passes through walls and floors.

O. Size and type of conduit and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer’s recommendations and NEC requirements, except as noted elsewhere.

P. Include one pull string in each conduit 3/4 in. or larger.

Q. Control and status relays are to be located in designated enclosures only. These enclosures can include packaged equipment control panel enclosures unless they also contain Class 1 starters.

R. Conceal all conduit, except within mechanical, electrical, or service rooms. Install conduit to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment (e.g., HW pipes or flues).

S. Secure conduit with conduit clamps fastened to the structure and spaced according to code requirements. Conduit and pull boxes may not be hung on flexible duct strap or tie rods. Conduits may not be run on or attached to ductwork.

T. Adhere to this specification's Division 26 requirements where conduit crosses building expansion joints.

U. The controls contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

V. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 1 m (3 ft) in length and shall be supported at each end.. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

W. Conduit must be adequately supported, properly reamed at both ends, and left clean and free of obstructions. Conduit sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

3.7 COMMUNICATION WIRING:

A. The controls contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification.

B. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.

C. Do not install communication wiring in raceway and junction boxes containing Class 1 or other Class 2 wiring from another trade such as fire alarm or security..

D. Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

E. Controls contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

F. All runs of communication wiring shall be unspliced length when that length is commercially available.

G. All communication wiring shall be labeled to indicate origination and destination data.

H. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.8 FIBER OPTIC CABLE SYSTEM:

A. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within cable manufacturer's specifications.

B. All cabling and associated components shall be installed in accordance with manufacturers' instructions. Minimum cable and unjacketed fiber bend radii, as specified by cable manufacturer, shall be maintained.

C. All terminations need to be made into a patch panel, designed for such use. Free air terminations with patch panels are prohibited.

3.9 INSTALLATION OF SENSORS:

A. General:

1. Install sensors in accordance with the manufacturer's recommendations.
2. Mount sensors rigidly and adequately for the environment within which the sensor operates.
3. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.
4. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.
5. All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.
6. Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.

B. Not used

C. Instrumentation Installed in Piping Systems.
1. Thermometers and temperature sensing elements installed in liquid systems shall be installed in thermowells.
2. Gauges in piping systems subject to pulsation shall have snubbers.

D. Temperature Limit Switch.

1. A temperature limit switch (Low Temperature Detector) shall be provided to sense the temperature.
2. Manual reset limit switches shall be installed in approved, accessible locations where they can be reset easily.
3. The temperature limit switch sensing element shall be installed in a serpentine pattern and in accordance with the manufacturer's installation instructions.
4. Each bend shall be supported with a capillary clip. Provide 3 m of sensing element for each 1 m2 (1 ft of sensing element for each 1 ft2) of coil area.

E. Not used

F. Not used

G. Not used

H. Water Differential pressure sensors.

1. Differential pressure sensors shall be installed with valved taps into the piping to ensure serviceability without draining the system

2. Sensors shall be mounted with bleed valves
3. After sensor installation any air shall be eliminated using the bleed valves to ensure reading accuracy
4. The sensors shall be located to ensure accessibility

I. Not used

3.10 NOT USED

3.11 ACTUATORS:

A. Not used.

B. Electric/Electronic

1. Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° available for tightening the damper seals. Actuators shall be mounted following manufacturer's recommendations.
2. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

3.12 WARNING LABELS AND IDENTIFICATION TAGS

A. Equipment and Device labeling:

1. Labels and tags shall be keyed to the unique identifiers shown on the As-Built drawings.
2. All Enclosures and DDC Hardware shall be labeled.
3. Airflow measurement arrays shall be tagged to show flow rate range for signal output range, duct size, and pitot tube AFMS flow coefficient.
4. Tags shall be plastic or metal and shall be mechanically attached directly to each device or attached by a metal chain or wire.
5. Labels exterior to protective enclosures shall be engraved plastic and mechanically attached to the enclosure or DDC Hardware.
6. Labels inside protective enclosures may be attached using adhesive, but shall not be hand written.
7. Identify all other control components with permanent labels. All plug-in components shall be labeled such that removal of the component does not remove the label.
8. Identify room sensors relating to terminal box or valves in permanent ink inside the door of the sensor.
9. Manufacturers' nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

B. Identification of Tubing and Wiring

1. All wiring and cabling including that within factory-fabricated panels shall be labeled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.

2. Permanently label or code each point of field terminal strips to show the instrument or item served.

3.13 IDENTIFICATION OF HARDWARE AND WIRING:

A. All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.

B. Permanently label or code each point of field terminal strips to show the instrument or item served.

C. Identify control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.

D. Identify room sensors relating to terminal box or valves with permanent ink inside the door of the sensor.

E. Manufacturers' nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

F. Identifiers shall match record documents.

3.14 PROGRAMMING:

A. Provide sufficient internal memory for the specified sequences of operation and trend logging. There shall be a minimum of 25% of available memory free within the primary controller for future use.

B. Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index. Point Naming standard shall be agreed upon between owner and BAS contractor prior to any programming being written. Refer to Submittals section in the General Section.

C. Software Programming

1. Provide programming for the system and adhere to the sequences of operation provided. The contractor also shall provide all other system programming necessary for the operation of the system, but not specified in this document. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation and be of different font and color in text editor. Use the appropriate technique based on one of the following programming types:

a. Text-based:

1) Must provide actions for all possible situations
2) Must be modular and structured
3) Must be commented
4) Must provide line by line programming and compilation wizard to allow for ease of editing.

D. Operator Interface

1. Standard graphics—Provide graphics for all mechanical systems and floor plans of the building (architect is responsible for providing floor plans of job to the contractor). This includes each chilled water system, hot water system, chiller, boiler, air handler, and all terminal equipment. Point information on the graphic displays shall dynamically update. Show on each graphic all input and output points for the system. Also show relevant calculated points such as set points.
2. Show terminal equipment information on a "graphic" summary table. Provide dynamic information for each point shown.
3. The contractor shall provide all the labor necessary to install, initialize, start up, and troubleshoot all operator interface software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third-party software installation and integration required for successful operation of the operator interface.
4. Contractor shall provide necessary programming to create all reports referred to in Part 2 Operator Interface Software

3.15 CONTROL SYSTEM CHECKOUT AND TESTING

A. Perform a two-phase commissioning procedure consisting of field I/O calibration and commissioning, system commissioning and integrated system program commissioning. Document all commissioning information on commissioning data sheets that shall be submitted prior to acceptance testing. Commissioning work that requires shutdown of system or deviation from normal function shall be performed when the operation of the system is not required. The commissioning must be coordinated with the owner and construction manager to ensure systems are available when needed. Notify the operating personal in writing of the testing schedule so that authorized personnel from the owner and construction manager are present throughout the commissioning procedure.

B. Phase I – Field I/O Calibration and Commissioning

1. Verify that each control panel has been installed according to plans, specifications and approved shop drawings. Calibrate, test, and have signed off each control sensor and device. Contractor will fill out daily reports with the general contractor when this work is being done so that the general contractor can notify the owner if they want to review this work. Contractor will provide a detailed commissioning report showing that this work was done. Commissioning to include, but not be limited to:

    a. Sensor accuracy at 10, 50 and 90% of range.
    b. Sensor range.
    c. Verify analog limit and binary alarm reporting.
    d. Point value reporting.
    e. Binary alarm and switch settings.
    f. Actuator and positioner spring ranges if pneumatic actuation is utilized.
    g. Fail safe operation on loss of control signal, pneumatic air, electric power, network communications, etc.

C. Phase II – System Commissioning

1. Each BMS program shall be put on line and commissioned. The contractor shall, in the presence of the owner, his engineer or their designated representative, demonstrate each programmed sequence of operation and compare the results in writing. In addition, each

control loop shall be tested to verify proper response and stable control, within specified accuracy. System program test results shall be recorded on commissioning data sheets and submitted for record. Any discrepancies between the specification and the actual performance will be immediately rectified and re-tested.

2. The demonstration process shall follow that approved in Phase 1, The approved checklists and forms shall be completed for all systems as part of the demonstration.
3. The contractor shall provide at least one person equipped with two-way communication and shall demonstrate actual field operation of each control process for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the response, and action of every point and system while under control. Any test equipment required to prove the proper operation shall be provided by and operated by the contractor.
4. Demonstrate compliance with sequences of operation through all modes of operation.
5. Demonstrate complete operation of operator interface.
6. Additionally, the following items shall be demonstrated:

    a. DDC loop response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.
    b. Demand limiting (if specified in sequence). The contractor shall supply a trend data output showing the action of the demand-limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set point, and the status of sheddable equipment outputs.
    c. Optimum start/stop(if specified in sequence). The contractor shall supply a trend data output showing the capability of the algorithm. The change-of value or change-of-state trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.
    d. Interface to the building fire alarm system(if specified in sequence).
    e. Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the architect/engineer. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and electronic formats.

7. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

D. Acceptance

1. All tests described in this specification shall have been performed to the satisfaction of both the engineer and owner prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if

stated as such in writing by the engineer. Such tests shall then be performed as part of the warranty.

2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved for both phase I and phase II

3.16 CLEANING

A. The contractor shall clean up all debris resulting from their activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

B. At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.17 TRAINING

A. The Contractor shall provide competent instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed. Factory employed/certified instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal work hours of 8:00 a.m. to 4:30 p.m. weekdays. All sessions will be scheduled one week in advance. If no one shows up after one hour from the start time, that session will be forfeited.

B. Provide a minimum of four (4) on-site, on-line, or classroom training sessions throughout the contract period for personnel designated by the owner. Each session shall be a minimum of four (4) hours each

C. Provide two additional training sessions at 6 and 12 months following building's turnover. Each session shall be four hours long and must be coordinated with the building owner

D. The instructor(s) shall be factory-trained instructors experienced in presenting this material.

3.18 SEQUENCES OF OPERATION

A. Sequence of operations will be the same as shown on all jobs. No deviations will be made on this document for the sequences shown.

END OF SECTION 23 0900

SECTION 23 2113

HYDRONIC PIPING AND VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes piping, special-duty valves, and hydronic specialties for hot-water heating, makeup water for these systems; and blowdown drain lines.

B. Related Sections include the following:
1. Division 23 Section "Common Work Results for HVAC" for general piping materials and installation requirements.
2. Division 23 Section "Hangers and Supports for HVAC" for pipe supports, product descriptions, and installation requirements. Hanger and support spacing is specified in this Section.
3. Division 23 Section "Mechanical Vibration and Seismic Controls for HVAC" for flexible pipe support and anchorage product descriptions, and installation requirements.
4. Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for flexible pipe accessory product descriptions, and installation requirements.
5. Division 23 Section "Meters and Gages for HVAC" for thermometers, flow meters, and pressure gages.
6. Division 23 Section "Identification for HVAC" for labeling and identifying hydronic piping.
7. Division 23 Section "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.
8. Division 23 Section “HVAC Water Treatment” for chemicals, feeders and water treatment requirements.
9. Division 23 Section "Instrumentation and Controls" for temperature-control valves and sensors.

1.2 SUBMITTALS

A. Product Data: For each type of valve indicated. Include flow and pressure drop curves based on manufacturer's testing for valves, diverting fittings, manual calibrated balancing valves, and automatic flow-control valves.

B. Shop Drawings: Detail fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, expansion joints and loops, and their attachment to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Welding Certificates: Copies of certificates for welding procedures and personnel.

D. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Failed test results and corrective action taken to achieve requirements.

E. Maintenance Data: For hydronic specialties and special-duty valves to include in maintenance manuals specified in Division 01.

F. Piping, fittings, and accessories: For each type of materials indicated, including gaskets.

1.3 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to the ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. ASME Compliance: Comply with ASME B31.9, "Building Services Piping,"for belowground piping, for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.4 COORDINATION

A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate pipe sleeve installations for foundation wall penetrations.

C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations.

D. Coordinate pipe fitting pressure classes with products specified in related Sections.

E. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 03 Sections.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Grooved Mechanical-Joint Fittings and Couplings:

a. Anvil International, Inc.
b. Grinnell Mechanical Products; a division of Tyco Fire & Building Products.
c. National Fittings, Inc.
d. S. P. Fittings; a division of Star Pipe Products.
e. Victaulic Company of America.
f. Or equal.

2. Pressure-Reducing Valves:

a. Conbraco Industries, Inc.
b. Hersey
c. Febco

d. Watts Industries, Inc.; Watts Regulators.
e. Or equal.

3. Safety Valves:

a. Conbraco Industries, Inc.
b. ITT McDonnell & Miller Div.; ITT Fluid Technology Corp.
c. Kunkle Valve Division.
d. Spence Engineering Company, Inc.
e. Or equal.

4. Expansion Tanks:

a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Taco, Inc.
d. Wheatley
e. Or equal.

5. Air Separators and Air Purgers:
a. Armstrong Pumps, Inc.
b. Spiro Research Company;Spirotherm, Inc.
c. Taco, Inc.
d. Or equal

B. Or Equal: Where products are specified by manufacturers name and accompanied by the term "or equal", comply with provisions in Division 01 Section “Product Options and Substitutions”. Specific procedures must be followed before use of an unnamed product or manufacturer.

2.2 PIPING MATERIALS

A. General: Refer to Part 3 "Piping Applications" Article for applications of pipe and fitting materials.

2.3 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.

E. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (silver).

2.4 STEEL PIPE AND FITTINGS

A. Steel Pipe, NPS ¾ through NPS 1½: ASTM A 53, Type S (seamless) Grade A, Schedule 40, black steel, plain ends.

B. Steel Pipe, NPS 2 through NPS 10: ASTM A 53, Type S (seamless) and Type ERW (welded) Grade A or B, Schedule 40, black steel, plain ends.

C. Not used.

D. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53, Schedule 40, black steel; seamless.

E. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.

F. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.

G. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced.

H. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

I. Grooved Mechanical-Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47, Grade 32510 malleable iron; ASTM A 53, Type S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders designed to accept grooved end couplings.

J. Grooved Mechanical-Joint Couplings: Ductile- or malleable-iron housing and EPDM gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

K. Welding Materials: Comply with Section II, Part C, of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

L. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

M. Flexible Connectors and Expansion Joints: See Division 23, Section “Expansion Fittings and Loops for HVAC Piping”.

2.5 VALVES

A. Ball Valves: (Sizes NPS ½”– 2 ½””, typical)

1. Ball valves (1/2”-2”), shall be two-piece style, full port, bronze body (ASTM B62 or B584) with type 316 SS ball & stem and PTFE (or RPTFE) seats and seals. Valves shall be rated for 600 psig WOG & 150 psig SWP (non-shock). All valves shall have adjustable packing glands and blow-out proof (internally retained) stems and shall comply with the latest edition of MSS-SP-110. Threaded end (FNPT) ball valves only; use male adapters where required in soldered end applications. Supply valves with stem extensions which clear 2” of piping insulation when installed in insulated services.

a. Conbraco Industries, Inc; Apollo Division figure 77-140.

b. Milwaukee Valve figure BA400S.
c. Hammond Valve figure 8303A.
d. Nibco figure T-585-70-66.
e. Or equal.

B. Cast-Iron Gate Valves for heating hot water applications:

1. Manufacturers:

a. Type I, Cast-Iron, Rising-Stem Gate Valves:

1) Crane Co.; Crane Valve Group; Crane Valves.
2) Crane Co.; Crane Valve Group; Jenkins Valves.
3) Crane Co.; Crane Valve Group; Stockham Div.
4) Milwaukee Valve Company.
5) NIBCO INC.
6) Powell, Wm. Co.
7) Walworth Co.
8) Watts Industries, Inc.; Water Products Div.
9) Or equal.

2. Cast-Iron Gate Valves, General: MSS SP-70, Type I.

a. Class 150, OS&Y, Cast-Iron Gate Valves: Cast-iron body with bronze trim, renewable bronze seat rings, rising stem, and tapered solid-wedge disc.

C. Check Valves:

1. Sizes NPS ¾"– 2": Ball-Check, spring type, Class 150, MSS-SP-80, two-piece bronze body and seat, full port, blowout proof, threaded ends, stainless steel ball, stem, and spring, Teflon elastomers, Buna-N disc.

a. Crane Co.; Crane Valve Group; Crane Valves
b. Crane Co.; Crane Valve Group; Stockham Div.
c. NIBCO INC. T-585-70-IC.
d. Or equal.

2. Sizes NPS 2½"- larger: Swing Check, Type 1, Class 125, MSS-SP-71, cast-iron body, flanged with bronze seat and bronze trim, bolted cap.

a. Crane Co.; Crane Valve Group; Crane Valves. 373.
b. Crane Co.; Crane Valve Group; Stockham Div. G931.
c. NIBCO INC. F-918-B.
d. Or equal.

D. Pressure-Reducing Valves: Diaphragm-operated, bronze or brass body with low inlet pressure check valve, inlet strainer removable without system shutdown, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory set at operating pressure and have capability for field adjustment.

E. Safety Valves: Diaphragm-operated, bronze or brass body with brass and rubber, wetted, internal working parts; shall suit system pressure and heat capacity and shall comply with the ASME Boiler and Pressure Vessel Code, Section IV.

F. For hydronic systems pressure-independent modulating control valve, can be used. If used, balancing valve and associated automatic flow limiting device will not be required.

G. Refer to Part 3 "Valve Applications" Article for applications of each valve.

H. Combination Assemblies: Individual threaded components, ball valves, control valve, automatic flow limiting device of brass body construction, fitted with pressure and temperature test valves, strainer, flexible hoses, and designed for 300 psig at 250 deg F for duct or terminal mounted heating coils. See Campus Standard detail.

2.6 HYDRONIC SPECIALTIES

A. Manual Air Vent Bronze body ball valve with stainless steel ball; NPS ½.

B. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150-psig working pressure; 240 deg F operating temperature; with NPS 1/4 discharge connection and NPS 1/2 inlet connection. Provide only one automatic air vent in system at air separator.

C. Expansion Tanks: Welded carbon steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature with rustproof coating. Separate air charge from system water to maintain design expansion capacity by a flexible diaphragm securely sealed into tank. Include drain fitting and taps for pressure gage and air-charging fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Factory fabricate and test tank with taps and supports installed and labeled according to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, shipped with minimum of 12 psig charge.

D. Air Separators: Welded black steel; ASME constructed and labeled for 150 psig minimum working pressure and 250 deg F maximum operating temperature; tangential Viton seal and O-ring brass vent head and skim valve, copper coalescing medium, non-ferrous float, in-line inlet and outlet connections; threaded connections for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger; threaded blowdown connection. Provide units in sizes for full-system flow capacity with pressure loss performance of less than one foot of water, and maximum velocity of 4 feet per second, as manufactured by Spirotherm, or equal as manufactured by others with greater than line size inlet as required to meet performance requirement of less than one foot of water at design flow capacity.

E. Y-Pattern Strainers NPS 2 and smaller:

1. Strainers 2" and smaller for heating and air conditioning water service shall be based on Watts No. 777 or an equivalent strainer by Armstrong or equal, 400 psig WOG bronze body, threaded, Y-pattern, 20-mesh stainless steel screen, with a full size drain connection and ball valve.

F. Y-Pattern Strainers NPS 2-1/2 and larger:

1. Strainers 2-1/2" and larger for heating and air conditioning water service shall be based on Watts No. 77F-DI, Keckely Style “A”, or an equivalent strainer by Armstrong or equal, Class 125 cast-iron body, flanged, Y-pattern, stainless steel screen, with a drain connection and ball valve (as described elsewhere herein).

G. Suction Diffuser: Angle or straight pattern, 175-psig pressure rating, cast-iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory- or field-fabricated support.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot Water Heating (above ground):

1. NPS 1-1/2 and smaller: Type L copper; with 95-5 soldered wrought copper fittings.
2. NPS 2and larger: Black steel pipe, ASTM A53, Type S (seamless) or Type ERW (welded); with standard weight ASTM A234 forged steel fittings for butt-weld connection or 150 lb flanged; or grooved mechanical joint coupling and fittings with roll grooved mechanical joints.

B. Hot Water Heating (below ground):

1. Hot-Water Heating Piping Installed Belowground: Underground piping for lines shall consist of a factory prefabricated, pre insulated system suitable for direct burial, consisting of a carrier pipe, insulation, and a corrosion resistant outer casing. Prefabricated piping system shall be XtruTherm as manufactured by PermaPipe, Ferro-Therm as manufactured by Thermacor Process, L..P. or approved equal. All straight sections, expansion loops, fittings, anchors and other accessories shall be factory fabricated to job dimensions and designed to minimize the number of field welds. Each system layout shall be computer-analyzed by the piping system manufacturer to determine stress on the carrier pipe and anticipated thermal movement of the service pipe. The contractor shall design and provide expansion loops. Pipe stress shall not exceed 40% of allowable maximum pipe stress. The system design shall be in strict conformance with ANSI B31.1 latest edition. Piping shall be seamless, or Electric Resistance Welded.

2. Carrier Pipe: ASTM A 53, Grade A or B, Schedule 40 for pipe sizes under 12".

3. Fittings: ASTM A 234/A 234M, forged steel welding type.

4. Joints: Welded, or 150 lb flanged.

5. Insulation: Polyurethane, spray applied, nominal density 2 pounds per cubic foot foam for straight sections and preformed foam for fittings - 2” thick.

6. Casing: Jacketing material shall be extruded, black, high density polyethylene (HDPE), having a minimum wall thickness of 125 mils for jacket sizes less than or equal to 12".

7. Fittings: Fittings shall be factory fabricated and provide sufficient straight lengths of pipe on each end to allow for field joints in straight piping only. Insulation and casing shall be the same as for the straight piping system.

8. End Seals: Moisture barrier end seals shall be factory applied, sealed to the jacket and carrier pipe. End seals shall be certified as having passed a 20-foot head pressure test. End seals shall be high temperature mastic completely sealing the exposed end of the insulation. Field applied end seals shall be installed at any field cut to the piping before continuing with the installation.

9. Field Joints: Straight run joints shall be field-insulated per the manufacturer's instructions,

C. Heating Water Pot Feeder:

1. Type L Copper: Type L copper: with 95-5 soldered wrought copper fittings.

D. Equipment Connections

1. NPS 2 and smaller: Use union connections.
2. NPS 2-1/2 and larger: Use flange connections.
3. Dissimilar metals: Where piping is connected to equipment with different materials, such as ferrous to copper, use brass union, brass coupler, brass pipe/nipple in order to prevent electrolysis.
4. Valves: Provide shut-off duty isolation valves and strainers at all equipment.
5. Flexible Piping Connectors: Provide flexible piping connectors at each piece of equipment unless acoustic consultant determines such devices are not required to meet project sound and vibration performance requirements.

E. Condensate Drain Lines: Type L drawn-temper copper tubing with soldered joints.

3.2 VALVE APPLICATIONS

A. General-Duty Valve Applications for hydronic systems unless otherwise noted, use the following valve types:

Type	Minimum Size	Maximum Size	Valve Service:
Ball	1/2”	2 -1/2 ”	Shut-off, and Throttling duty.
Gate, rising stem (hot water)	2½”	n/a	Shut-off duty.
Ball - Check (hot water)	¾”	2”	Check valve.

B. Install main building shut-off valves for hydronic systems.

C. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line.

D. Not used.

E. Hydronic systems which utilize flow limiting devices as balancing means shall include flow limiting devices on all system user branch take-off's at heat exchange device for system uniformity and proper system balance and operation.

F. See Division 23 Section "Instrumentation and Controls" for hydronic control valve requirements.

G. Install check valves at each pump discharge and elsewhere as required to control flow direction.

H. Install safety valves on hot-water generators and elsewhere as required by the ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to floor. Comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, for installation requirements.

I. Install pressure-reducing valves on hot-water generators and elsewhere as required to regulate system pressure.

3.3 PIPING INSTALLATIONS

A. Refer to Division 23 Section "Common Work Results for HVAC" for basic piping installation requirements.

B. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

C. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

D. Install piping level or at a uniform grade of 0.2 percent in direction of flow or a drain.

E. Reduce pipe sizes using eccentric reducer fitting installed with level side up- top flat.

F. Install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.

G. Install strainers on supply side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

H. Anchor piping for proper direction of expansion and contraction.

I. Do not use groove-joint fittings on insulated piping system, unless insulation system is specifically designed for groove-joint fittings.

J. Piping penetrations shall be carefully detailed. Insulation through penetrations shall be continuous.

K. Bushings and short nipples shall not be used.

L. Avoid pipe joints located over, or within 2 feet of electrical equipment. If it cannot be avoided provide with drip pans.

M. Teflon tape shall be utilized for threaded pipe joints.

N. Provide pipe and fittings of similar materials so dielectric fittings are not needed; i.e. only brass and bronze fittings with copper piping.

O. Grooved Mechanical-Joint Fittings and Couplings:

1. Piping shall be roll grooved only. Cut groove piping is not allowed.
2. Gaskets shall be EPDM.
3. Install per manufacturer's installation instructions.

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports for HVAC." Comply with requirements below for maximum spacing of supports.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

NPS	Maximum span (feet)	Minimum rod size (inches)
3/4	7'	¼"
1	7 '	¼"
1-1/2	9'	3/8"
2	10'	3/8"
2-1/2	11'	3/8"
3	12'	3/8"
4	14'	½"
6	17'	½"
8	19'	5/8"

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

NPS	Maximum span (feet)	Minimum rod (inches)
3/4	5 ‘	1/4 “
1	6 ‘	1/4 “
1-1/2	8 ‘	3/8 “
2	8 ‘	3/8 “
2-1/2	9 ‘	3/8 “
3	10 ‘	3/8 “

E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Refer to Division 23 Section "Common Work Results for HVAC" for joint construction requirements for soldered and brazed joints in copper tubing; threaded, welded, and flanged joints in steel piping.

3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat exchanger, and elsewhere as required for system air venting.

B. Install one automatic air vent per system in mechanical equipment rooms only at air separator for system air venting.

C. Install in-line air separators in pump suction lines. Install drain valve on units NPS 2 and larger.

D. Install expansion tanks on floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system design requirements.

E. Provide pot-feeder in heating systems.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be same as for equipment connections.

B. Install shut-off valves, strainers, accessories, and flexible hose threaded connections.

C. Install control valves in accessible locations close to connected equipment.

D. Never install bypass piping around control valves.

E. Install ports for pressure and temperature gages at equipment inlet connections.

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and B31.1 as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium.
2. While filling system, use vents installed at high points of system to release trapped air. Use drains installed at low points for complete draining of liquid.
3. Check expansion tanks to determine that they are not air bound and that system is full of water.
4. Subject piping system to hydrostatic test at 150 PSI or 1.5 times the design pressure, whichever is greater, for four hours. There shall be no decrease in pressure over the four hour test period.Isolate equipment subject to damage from test pressure. Make no test against a service valve or meter. Isolate from the system all existing piping and new or existing equipment that may be damaged by test pressure. Test only new piping unless instructed otherwise. Final connection between new and existing piping shall be tested at normal system operating pressures and monitored for leaks for three working days. Verify that stress due to pressure at bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied, examine piping, joints, and connections for leakage throughout the testing period. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

3.9 ADJUSTING

A. Perform these adjustments before operating the system:

1. Open valves to fully open position.
2. Check pump for proper direction of rotation.
3. Set automatic fill valves for required system pressure.
4. Check air vent at air separator and determine if it is operating freely (automatic type).
5. Check air vents at high points of system and bleed air completely (manual type).
6. Set temperature controls so all coils are calling for full flow.
7. Check and set operating temperatures of heating and chilled water systems to design requirements.
8. Lubricate motors and bearings.

3.10 CLEANING

A. Flush hydronic piping systems with clean water. Remove and clean or replace strainer screens. After cleaning and flushing hydronic piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

B. System shall be chemically treated per section 23 2500.

END OF SECTION 23 2113

SECTION 23 2500

HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes water-treatment systems for the following:

1. Cleaning of piping systems.
2. Chemical feeder equipment.
3. Treatment for closed systems heating water systems.

1.2 SUBMITTALS

A. Submit manufacturer's installation instructions.

B. Include data on chemical feeder, procedures, and treatment programs.

C. Include step-by-step instructions on test procedures including target concentrations.

D. Submit product data indicating chemical treatment materials, chemicals, and equipment.

E. Submit reports indicating start-up of treatment and systems are completed and operating properly.

F. Submit reports indicating analysis of system water after cleaning and after treatment.

G. Provide detailed procedure for cleaning and passivating system for university approval, or follow University established procedure.

1.3 QUALITY ASSURANCE

A. University's Representative Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience. Company shall have local representatives with water analysis laboratories and full time service personnel.

1.4 REGULATORY REQUIREMENTS

A. Conform to applicable codes for addition of non- potable chemicals to building mechanical systems, and for delivery to public sewage systems.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the specified manufacturers.
   1. Garrat-Callahan (campus standard)

   2. Or Equal: Where products are specified by manufacturers name and accompanied by the term "or equal", comply with provisions in Division 01 Section "Product Options and Substitutions". Specific procedures must be followed before use of an unnamed product or manufacturer.

2.2 MATERIALS

A. System Cleaner:

   1. Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products; sodium tripoly phosphate and sodium molybdate.
   2. Algaecide; chlorine release agents such as sodium hypochlorite or calcium hypochlorite, or microbiocides such as quarternary ammonia compounds, tributyl tin oxide, methylene bis (thiocyanate), or isothiazolones.
   3. Or equal.

2.3 CHEMICAL FEEDING EQUIPMENT

A. Not used.

B. Chemical Feed Tanks:

   1. Chemical pot feeders shall be provided at each secondary heating system and in stand-alone buildings for heating water systems.
   2. Not used.
   3. Provide a minimum of a one-gallon by-pass chemical feed tank. Tank shall be piped on discharge piping to pump, across the pump shut-off valve. This location is to eliminate chemical slugging of pump seals. Chemicals shall be circulated throughout the total system before reaching pump seals.

2.4 CHEMICALS FOR CLOSED SYSTEMS

A. The University will supply chemicals as used on campus for system start-up water treatment. Coordinate quantities required with the University's representative. Treatment will occur after piping has been cleaned and tested. If because of the contractor's error, additional chemicals are needed, the University will provide chemicals at contractor's expense.

B. Provide 48 hours notice when chemical treatment is needed. Piping system must have been tested and approved and completely cleaned and flushed prior to this request. Contractor is responsible for cleaning and passivating the system prior to system start water treatment. Dispose of cleaning solution in accordance with applicable laws and regulations.

C. Coupon racks are not required at buildings unless directed by the University.

PART 3 - .EXECUTION

3.1 PREPARATION

A. Systems shall be operational, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system. Place terminal control valves in open position during cleaning.

3.2 CLEANING SEQUENCE

A. Add cleaner to closed systems at concentration as recommended by manufacturer but not less than one pound per 100 gallons of water.

B. Use neutralizer agents on recommendation of system cleaner supplier.

C. Flush open systems with clean water for one-hour minimum. Drain completely and refill.

D. Remove, clean and replace strainer screens.

E. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

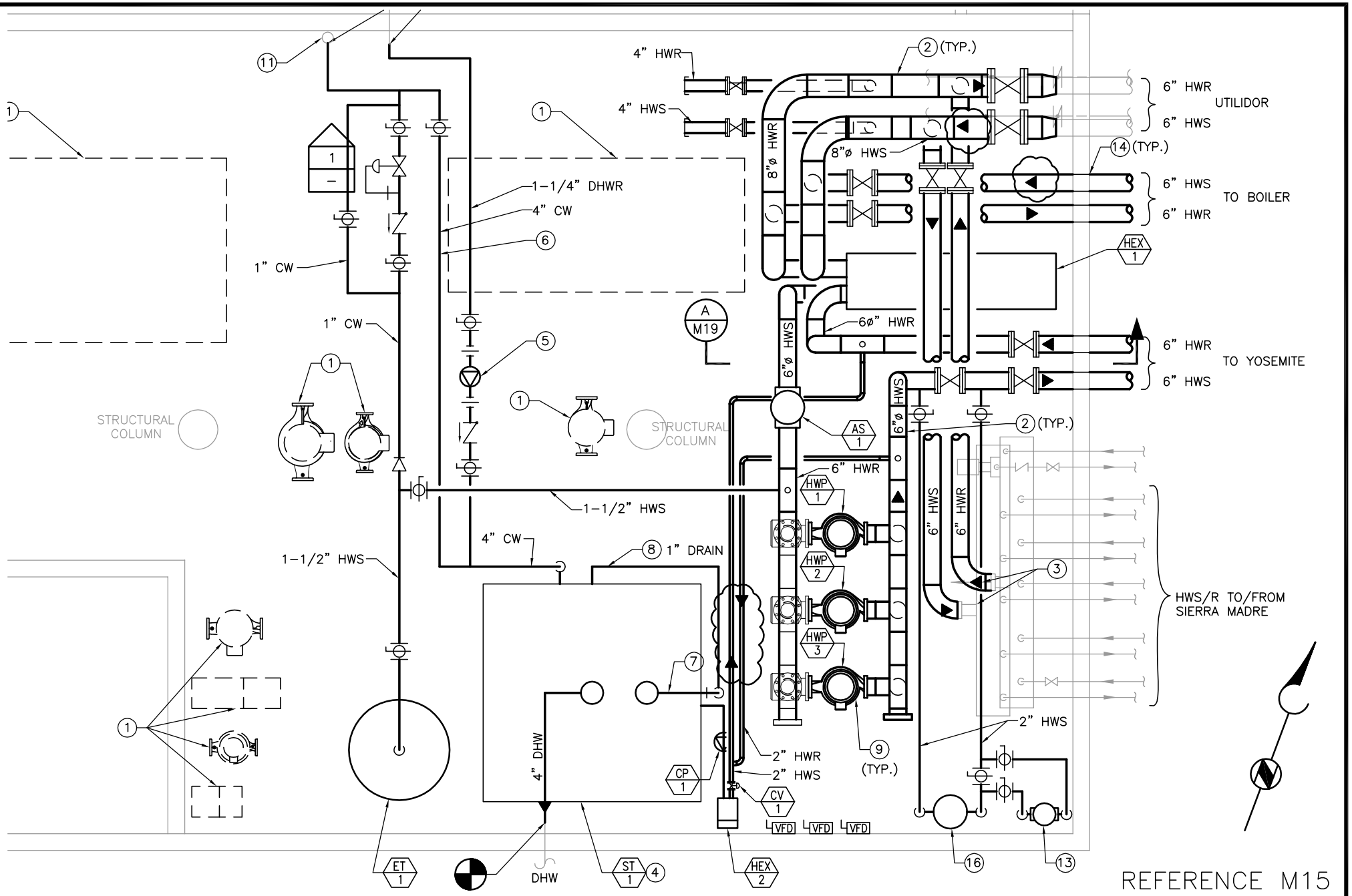
3.3 CLOSED SYSTEM TREATMENT

A. Provide one bypass feeder on each system. Install isolating and drain valves and necessary piping. Install around globe valve downstream of circulating pumps unless indicated otherwise.

B. Introduce closed system treatment through bypass feeder when required or indicated by test.

C. Provide filter system for closed loop system. Install isolating and drain valves and necessary piping. Install around globe valve downstream of circulating pumps unless indicated otherwise.

END OF SECTION 23 2500



GOSS ENGINEERING, INC.
CORONA, CALIFORNIA PH: (951) 340-1977 FX: (951) 340-1090

SUBMITTED _____ DATE _____
PROJECT MANAGER

APPROVED _____ DATE _____

CALIFORNIA STATE UNIVERSITY, SAN LUIS OBISPO

YOSEMITE REPIPE

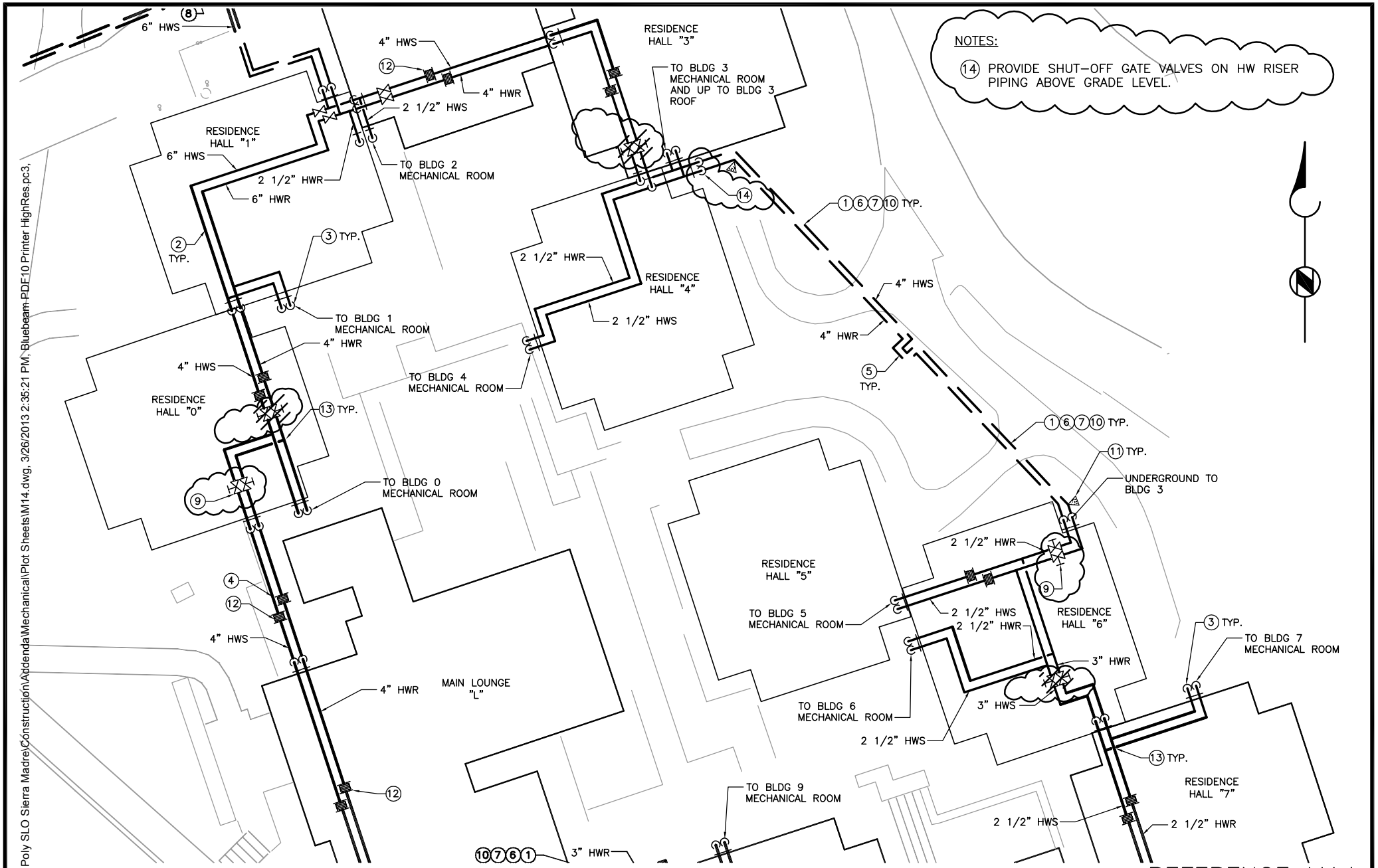
SIERRA MADRE

COGEN ROOM IMPROVEMENT PLAN

FILE 111-02-03

DATE 3/26/13

DRAWING NUMBER SK-1



REFERENCE M14

GOSS ENGINEERING, INC.
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SUBMITTED _____ DATE _____
PROJECT MANAGER

APPROVED _____ DATE _____

CALIFORNIA STATE UNIVERSITY, SAN LUIS OBISPO

YOSEMITE REPIPE

YOSEMITE

HOT WATER PIPING INSTALLATION PLAN

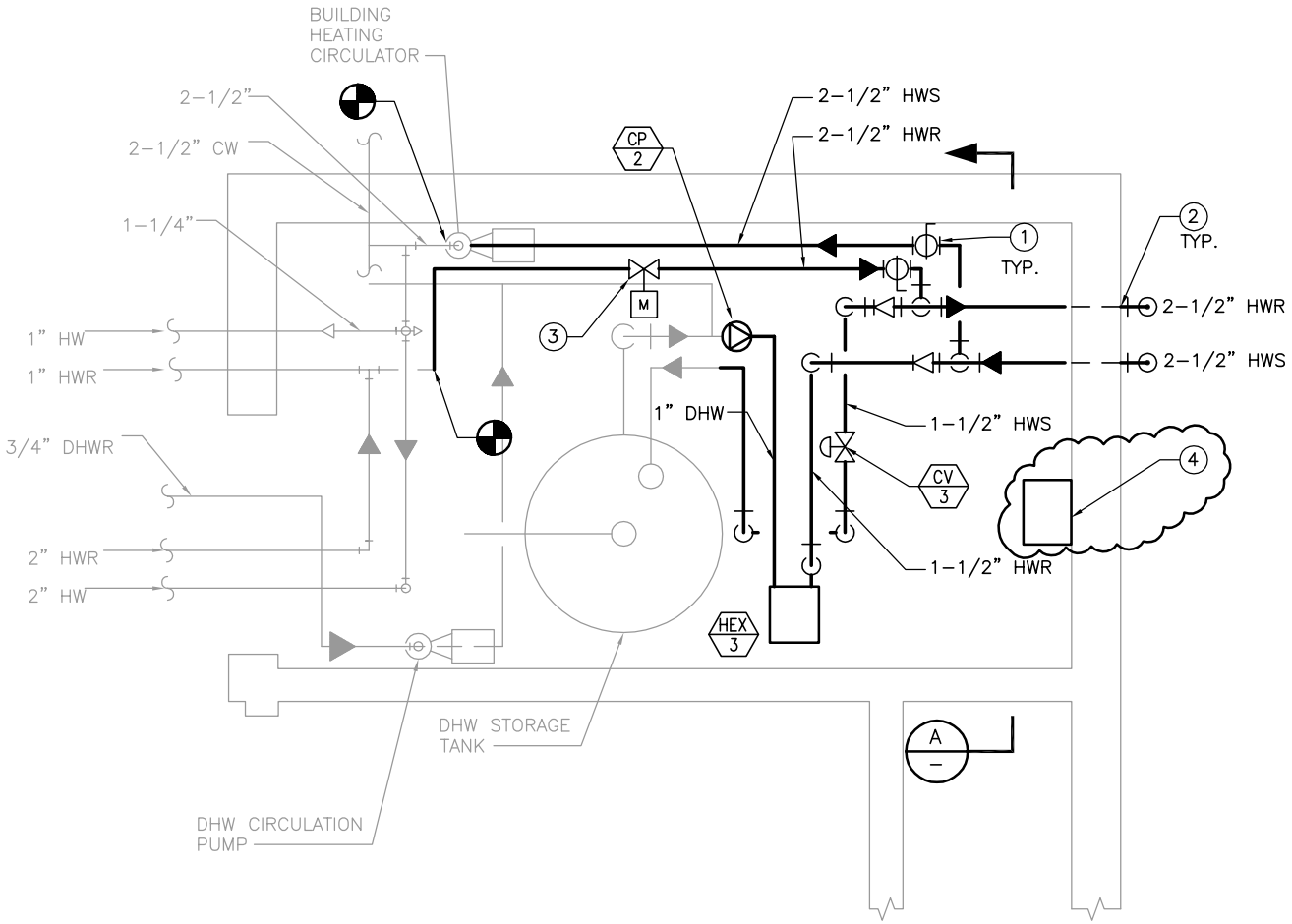
FILE 111-02-03

DATE 3/26/13

DRAWING NUMBER SK-2

NOTES:

(4) APPROXIMATE LOCATION OF FLOOR LEVEL NETWORK CONTROL PANEL, TOWER 8 ONLY. ELECTRICAL CONTRACTOR TO PROVIDE 120V POWER FROM NEAREST J-BOX IN MECHANICAL ROOM.



REFERENCE M18

GOSS ENGINEERING, INC.
CORONA, CALIFORNIA PH: (951) 340-1977 FX: (951) 340-1090

SUBMITTED _____ DATE _____
PROJECT MANAGER

APPROVED _____ DATE _____

CALIFORNIA STATE UNIVERSITY, SAN LUIS OBISPO

YOSEMITE REPIPE

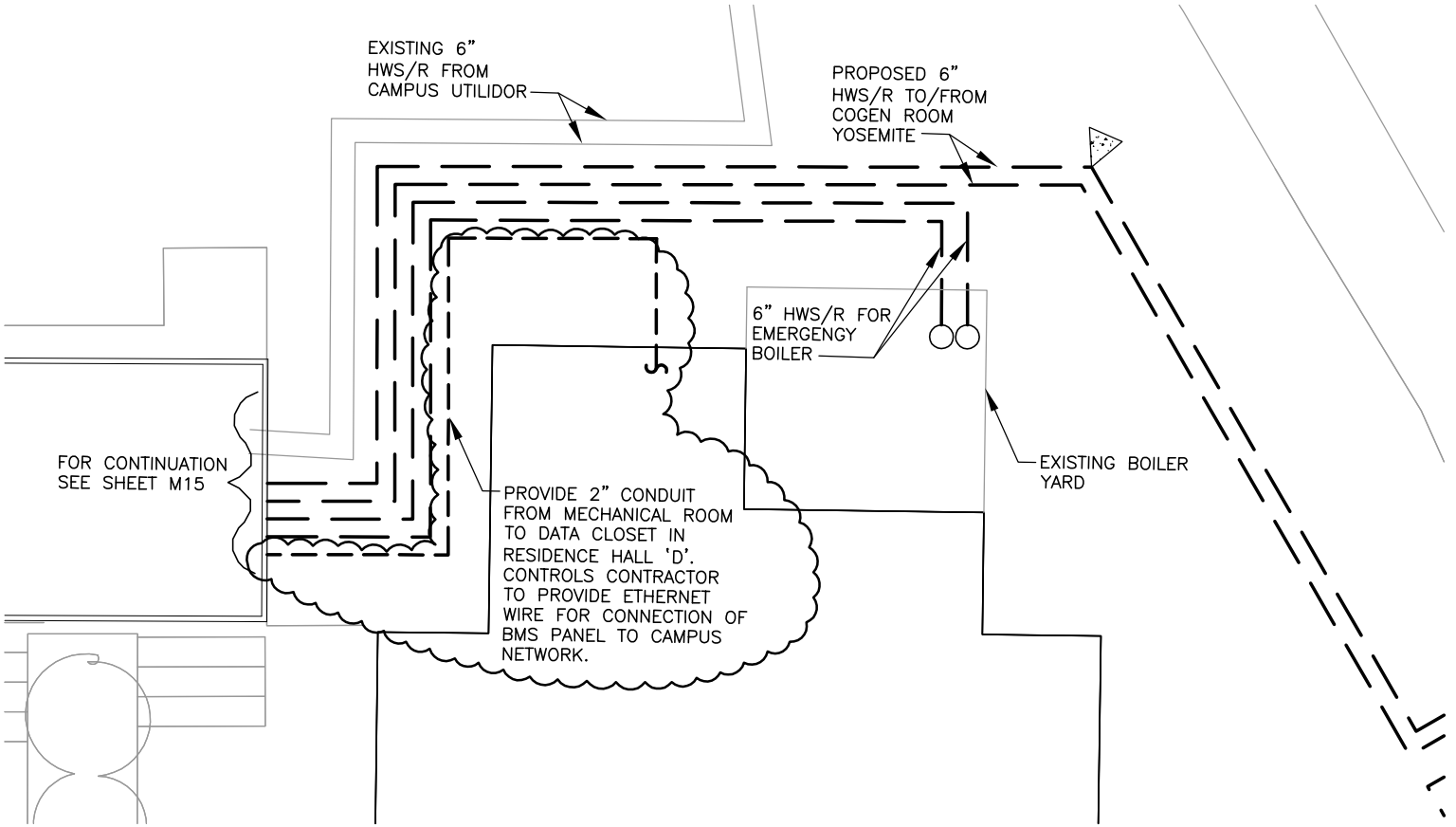
YOSEMITE

YOSEMITE TOWER 0-9 MECHANICAL ROOM HW

FILE 111-02-03

DATE 3/26/13

DRAWING NUMBER SK-3



REFERENCE M19

GOSS ENGINEERING, INC.
CORONA, CALIFORNIA PH: (951) 340-1977 FX: (951) 340-1090

SUBMITTED _____ DATE _____
PROJECT MANAGER
APPROVED _____ DATE _____

CALIFORNIA STATE UNIVERSITY, SAN LUIS OBISPO

YOSEMITE REPIPE

SIERRA MADRE SITE PLAN

FILE 111-02-03
DATE 3/26/13
DRAWING NUMBER SK-4