Washington State
DEPARTMENT OF
ENTERPRISE SERVICES

Addendum #02
Issued: Thursday, May 2, 2024
Informational Meeting Sign-In, Presentation, Questions

Project:	2022-004
Project Name:	Cascadia Gateway CC5 Building
Phase:	Request for Qualifications
Meeting Location:	Hybrid Meeting (Teams + Cascadia College Building CC2 Room 260)
Date/Time:	April 29, 2024 at 10:00 AM PT with site walk following the meeting
DES PM:	Suzanne Gilbert, Architect, PM; suzanne.gilbert@des.wa.gov

NOTICE TO ALL POTENTIAL RESPONDENTS

The Request for Qualifications (RFQ) is modified as set forth in this Addendum. The original RFQ documents and any previously issued addenda remain in full force and effect, except as modified by this addendum, which is hereby made part of the RFQ. Respondent shall take this Addendum into consideration when preparing and submitting its Statement of Qualification.

Visit our webpage for additional information: https://des.wa.gov/services/facilities-and-leasing-management/design-build-gccm-alternative-public-works-projects/gccm-project-selections

Last day to submit questions for this RFQ-RFP for Phase 1 (SOQ Submittal) is 5/6/2024 by 5:00 PM PT.

This Addendum consists of multiple parts:

- Questions/Answers
- Owner-issued changes of procurement requirements
- Teams Informational Meeting Sign-In
- Attachments

1. Questions and Answers:

Questions	Answers
Attachment 6 and Reference Document 7 are referenced in the RFQ-RFP but not available in the Articles/Attachments/Reference Documents link, where can I find them?	The initial upload for Attachment 6 and Reference Document 7 was not successful. Both documents have now been successfully uploaded and can be found here: https://wades.box.com/s/8hbu105v4gj9337lowyf1ei36do53lzi
9.0 PHASE ONE – RFQ EVALUATION CRITERIA: Bonding – not scored. Proposers shall include a statement from their bonding agent indicating	**Clarification:** The bond statement *will not be counted* as pages in the RFQ total of 30-page count.

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the commitment to bond this project shall be included should the Proposer be selected as a Finalist to proceed to Phase 2. The statement shall include the bonding company name, agent's name, address, telephone, fax, and email address. Failure to meet this bonding requirement is a cause for disqualification	
May drones be used for mapping the site and helping with the proposal?	Yes, it must be coordinated with Cascadia College staff and Campus Safety. Please contact: Miles Alexander Interim Director of Facilities and Capitol Projects malexander@cascadia.edu Shawna Pitts Interim VP Administrative Services spitts@cascadia.edu
Who will be on the selection committee?	The members participating in the selection process will be: Department of Enterprise Services Suzanne Gilbert, Project Manager Jonathan Martin, Project Manager Cascadia College Shawna Pitts, Interim VP for Administration Services Meagan Walker, VP for External Relations & Planning Mahlum Architects Scheer Chan, Project Manager & Principal Designer
How will the cost for the utilities investigation (potholing) be covered?	The utilities investigation (potholing) will be a cost to the contractor and paid from the total preconstruction fee of **$200,000.00**
Will the Informational Meeting presentation on 4/29 be shared on the DES website?	A PDF of the Informational Meeting is included as part of this addendum.
What does the existing transformer next to proposed CC5 building on Campus Way serve?	The existing transformer currently serves CC1 & CC2 buildings as well as the North Parking Garage. These buildings also feed street lighting along Campus Way directly next to each

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	building. Further investigation of record documentation is required.
Are the resumes included in the page count limitation?	Yes, they are included in the page count.
Can we use any 11 x 17 pages in the SOQ?	You can use 11 x 17 format, but it will be counted as 2 pages.
Is there any early funding available to release early procurement/civil packages besides potholing?	No early funding has been confirmed, but options are being investigated.

2. The following are changes to the procurement requirements:

Reference Section	Change
Reference Documents Volume 2 ***no changes to content, only to headers**	PDF page numbers 236-250 the header should read as follows: 23 05 93 TESTING ADJUSTING AND BALANCING PDF page numbers 274-297 the header should read as follows: 23 07 16 HVAC EQUIPMENT INSULATION The updated individual specification sections are included in this Addendum.
Reference Document 2 Volume 3 ***no changes to content, only to headers**	PDF page numbers 216-228 the header should read as follows: 28 31 11 FIRE ALARM AND DETECTION SYSTEMS The updated individual specification section is included in this Addendum.

3. Sign-in as captured in chat:

Name	Email
Scheer Chan	SChan@mahlum.com
Pitts, Shawna	spitts@cascadia.edu
Gilbert, Suzanne (DES)	suzanne.gilbert@des.wa.gov
Gizzi, Chris (DES)	chris.gizzi@des.wa.gov
Diane Vandewall - Krazan	dianevandewall@krazan.com
Jillian Strobel	Jillian-Strobel@Hoffmancorp.com
Madhu Kannan	madhuk@gencapgc.com

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Mark Cork	mcork@mahlum.com
Sheryl Bushaw	sherylb@sellen.com
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Martin, Jonathan B. (DES)	jonathan.martin@des.wa.gov
Stewart Potter	stewart.potter@bayley.net
Sara Delahan	sarad@cornerstonegci.com
John Zhang	John.Zhang@grahamus.com
Tina Spah	taylor@bxwa.com, production@bxwa.com

4. **Attachments:**
   a. Info Meeting Sign-In for people attending in person
   b. Informational Meeting Presentation
   c. Individual Specification sections
      i. Section 23 05 93 Testing Adjusting and Balancing
      ii. Section 23 07 16 HVAC Equipment Insulation
      iii. Section 28 31 11 Fire Alarm and Detection Systems

This addendum does not amend the due date or time for submission of Statements of Qualifications.

End of Addendum #02

DES

Washington State DEPARTMENT OF ENTERPRISE SERVICES

Date: 4-29-24

Project Number:

Project Description:

Name	Agency/Firm	Phone	E-mail (print clearly)
Jeff Cook	Hoffman Const.	206 482 0797	Jeff-Cook@Hoffmancorp.com
Ben Larson	Hoffman Construction	206-396-5038	Ben-Larson@hoffmancorp.com
Anthony Pittman	Mortenson	425-681-7693	Anthony.Pittman@Mortenson.com
Jennifer Kim	Mortenson	425-686-2461	Jennifer.kim@mortenson.com
Dan Kathman	Andersen Construction	253.318.9548	dkathman@asistructures.com
John Zhang	Graham	602.321.9939	John.Zhang@GrahamUS.com
Triton Cole	Clark Construction	(206)945-2153	Triton.Cole@Clarkconstruction
Greg Groleau	Clark Construction	(206) 712 7660	greg.groleau@clarkconstruction.com
Joey Marr	Marpac Construction	(206) 393-7467	JoeyM@Marpac.net
Richard Teddy	Kiewit Bldg. Group	(206) 396-3573	richard.teddy@kiewit.com
Brad Rabenstein	H&E	(425) 758-5291	BRabenstei...@HE-Equipment...
Nick Moore	Clark Construction	760 330 0676	Nick.Moore@clarkconstruction.com
Rob Nemes	Skanska	206 771 1297	Rob.nemes@skanska.com

DES

Washington State
DEPARTMENT OF
ENTERPRISE SERVICES

Date: 4-29-24

Project Number:

Project Description:

Name	Agency/Firm	Phone	E-mail (print clearly)
Erin Gocke	Hoffman Const	206-683-0935	erin-gocke@hoffmancorp.com
Karin Grinzel	Bayley	2065107128	karin.grinzel@bayley.net
Bill Kent	Mortenson	206 778 8936	bill.kent@mortenson.com
Paige Adkinson	Mortenson	425 614 7179	paige.adkinson@mortenson.com
Ajla Selimic	Andersen Const	2066388137	aselimic@andersen-const.c
Chip Tull	Hoffman	509.339 5922	chip-tull@hoffmancorp.com
Marjorie Chang	Hoffman	2069532181	marjorie-chang@hoffmancorp.com
Aaron Olson	Turner	206 588 9055	aolson@tcco.com
KYLE KNAPP	CLARK CONSTRUCTION	510 600 2528	KYLE.KNAPP@CLARKCONSTRUCTION.COM
Aaron Kelley	Clark Const	206-308-6280	Aaron.Kelley@ClarkConstruction.com
MATT Uphaus	BN Builders	206 718 6131	MATT.Uphaus@bnbuilders.com
ROB ROBINSON	SKANSKA	206-406-5999	Rob.Robinson@skanska.com
CHRIS COLEMAN	BAYLEY	206.462.8127	chris.colemane Bayley.net

Washington State
DEPARTMENT OF ENTERPRISE SERVICES

Date:

Project Number:

Project Description:

Name	Agency/Firm	Phone	E-mail (print clearly)
MEGAN COFFLAND	BNBUILDERS	206-643-0162	Megan.coffland@bnbuilders.com
Tom Leptich	Skanska	206-459-7151	tom.leptich@skanska.com
Ike Burkett	Anderson	206-962-9454	iburkett@anderson[illegible]
Jason Heidal	ABSHER	253-341-7377	JASON.HEIDAL@ABSHERCO.COM
Griffin Collins	Absher	253-320-5642	griffin.collins@absherco.com
ERIC SCOTT	Cornerstone GC	206-371-3951	eric@cornerstonegci.com
DAVID KILLIAN	SKANSKA	206 999 5281	DAVID.KILLIAN@SKANSKA.COM
Jessica Fabro	BNBuilders	206-639-3501	JESSICA.FABRO@BNBUILDERS.COM
JOSH GOLDMAN	CORNERSTONE GC	206-818-5535	josh@CORNERSTONEGCI.COM

DES

Washington State
DEPARTMENT OF
ENTERPRISE SERVICES

Date: _____

Project Number: _____

Project Description: _____

Name	Agency/Firm	Phone	E-mail (print clearly)
JOHN JULIUS	Bayley Construction	503-995-8819	john.julius@bayley.net
Mike Palm	Sellen	206-392-2706	MikePa@sellen.com
Shaun Barry	Sellen	206.549.8785	Shaunb@sellen.com
RYAN WEEGER	SWINERTON	925.229.5638	RYAN.WEEGER@SWINERTON.COM
Rick Carte	ABSHER	425-223-1505	rick.carte@absherco.com
Bryan Gormley	Cornerstone	425 652 2341	bryan@cornerstonegc.com
Chris Hall	Anderson	206-305-[illegible]	[illegible]
Tanner Lyon	BN Builders	260-519-4024	tanner.lyon@bnbuilders.com
KYLE WALKER	KBG		kyle.walker@kbg.com

mahlum

Welcome!

Cascadia College CC5 Gateway Building

Informational Meeting

29 April 2024

Introductions

Department of Enterprise Services (Contracting Authority)
Facility Professional Services, Engineering & Architectural Services

*Suzanne Gilbert, Project Manager

Chris Gizzi, Assistant Program Manager

*Jonathan Martin, Project Manager

Cascadia College (Owner)

*Shawna Pitts, Interim Vice President for Administration Services

*Meagan Walker, Vice President for External Relations & Planning

Mahlum Architects (Designer)

Mark Cork, Principal in Charge

*Scheer Chan, Project Manager & Principal Designer

CASCADIA COLLEGE
BOTHELL

Agenda

- Project Description
- Key elements of the Request for Qualifications & Proposal
- Questions & Answers
- Site Walk

CASCADIA COLLEGE
BOTHELL

Cascadia College Gateway Building

Project Description

The CC5 Gateway Building will be a new front door to Cascadia College. This 37,600 sf four story building will serve as a welcoming entrance to the academic core and a beacon of Cascadia College's unique identity.

By bringing all student services under one roof, the Gateway Building will facilitate a seamless student support experience and provide welcoming and inclusive amenities to create a home for Cascadia College students.

CC5 Gateway Building: Project Goals

Sense of Belonging: Welcome and support every single student, especially new and first-year students, no matter their life experience or educational goal

Access & Inclusion to Services : Increase access to educational and student support services by making support services easy and inviting to navigate

Improve Student Service Delivery: Bolster student retention and achievement by considering models best suited to delivering services

Improve Collaboration: Make connections between Students

College Identity: Increase college's visibility on campus while surrounded by University of Washington Bothell buildings and signage

Feasibility: Establish a path forward by aligning design, budget, permitting requirements, and campus planning

CASCADIA COLLEGE
BOTHELL

Project Prioritization

Sense of Belonging

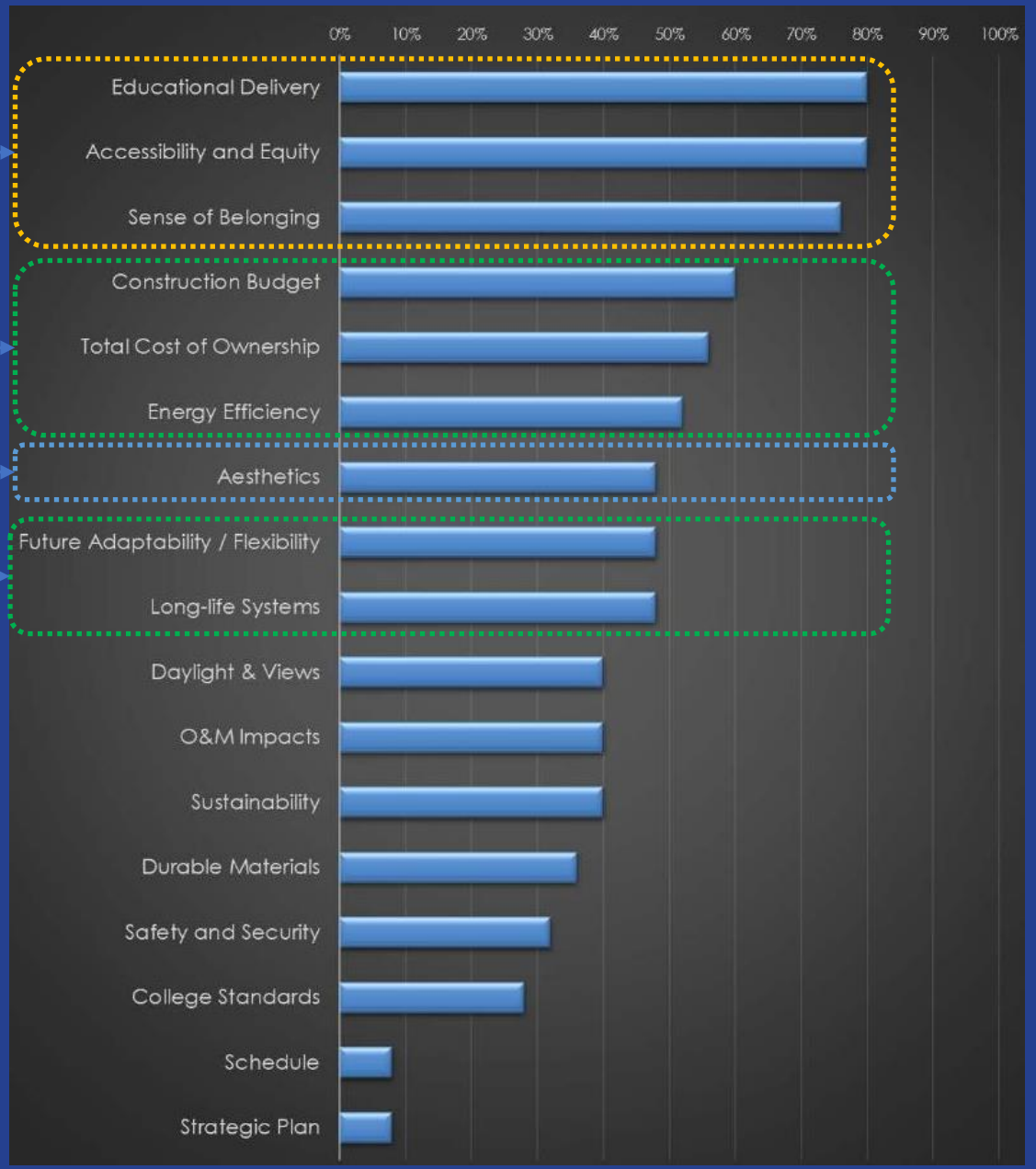
Access & Inclusion to Services

Improve Student Service Delivery

Improve Collaboration

Feasibility

College Identity



CASCADIA COLLEGE BOTHELL

Site Survey

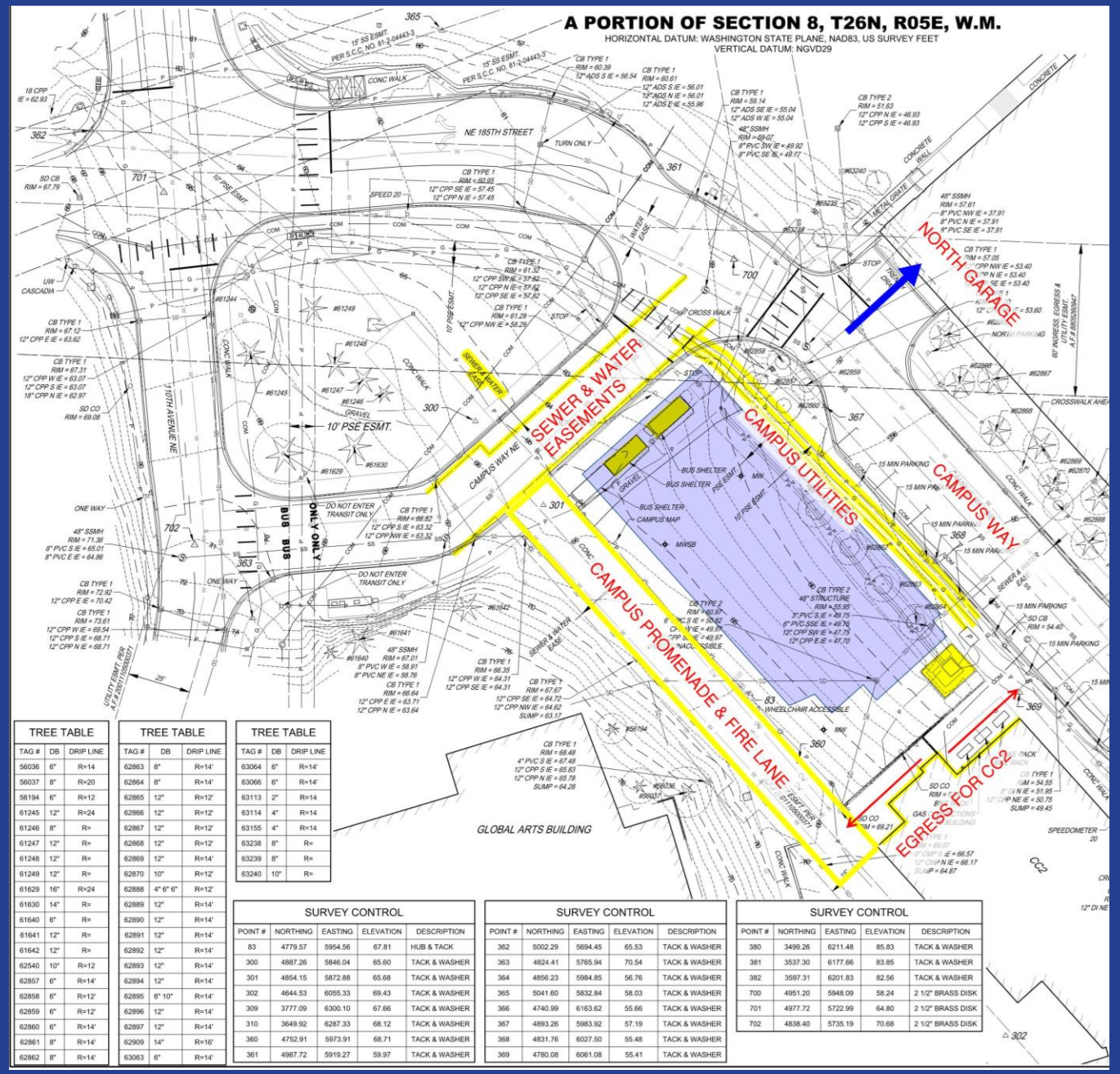
Easements & Utilities

Access

- Fire Lane
- North Garage
- Pedestrian Circulation
- Egress

Transformer

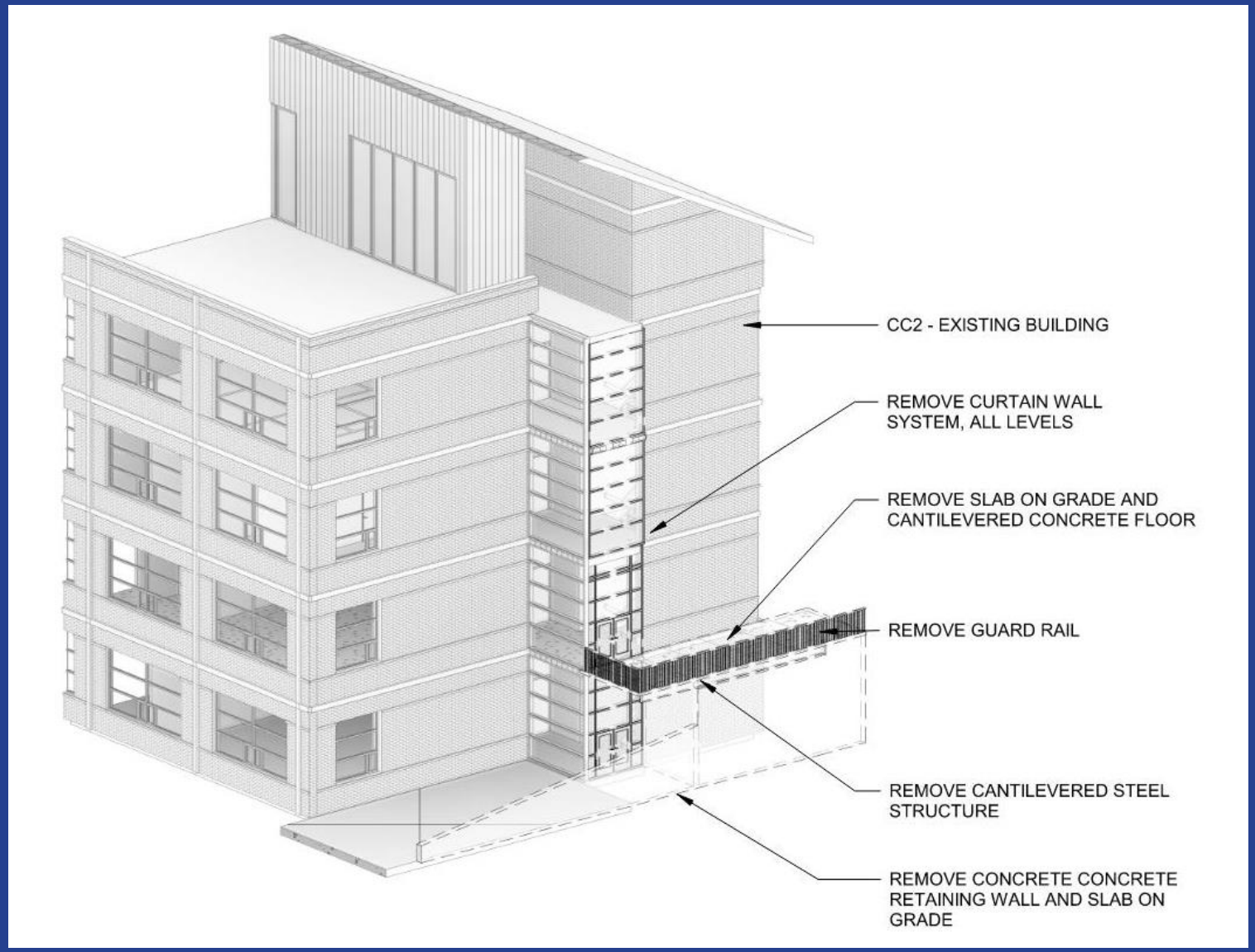
Bus Stop



Existing Conditions

Existing Conditions

Existing Conditions



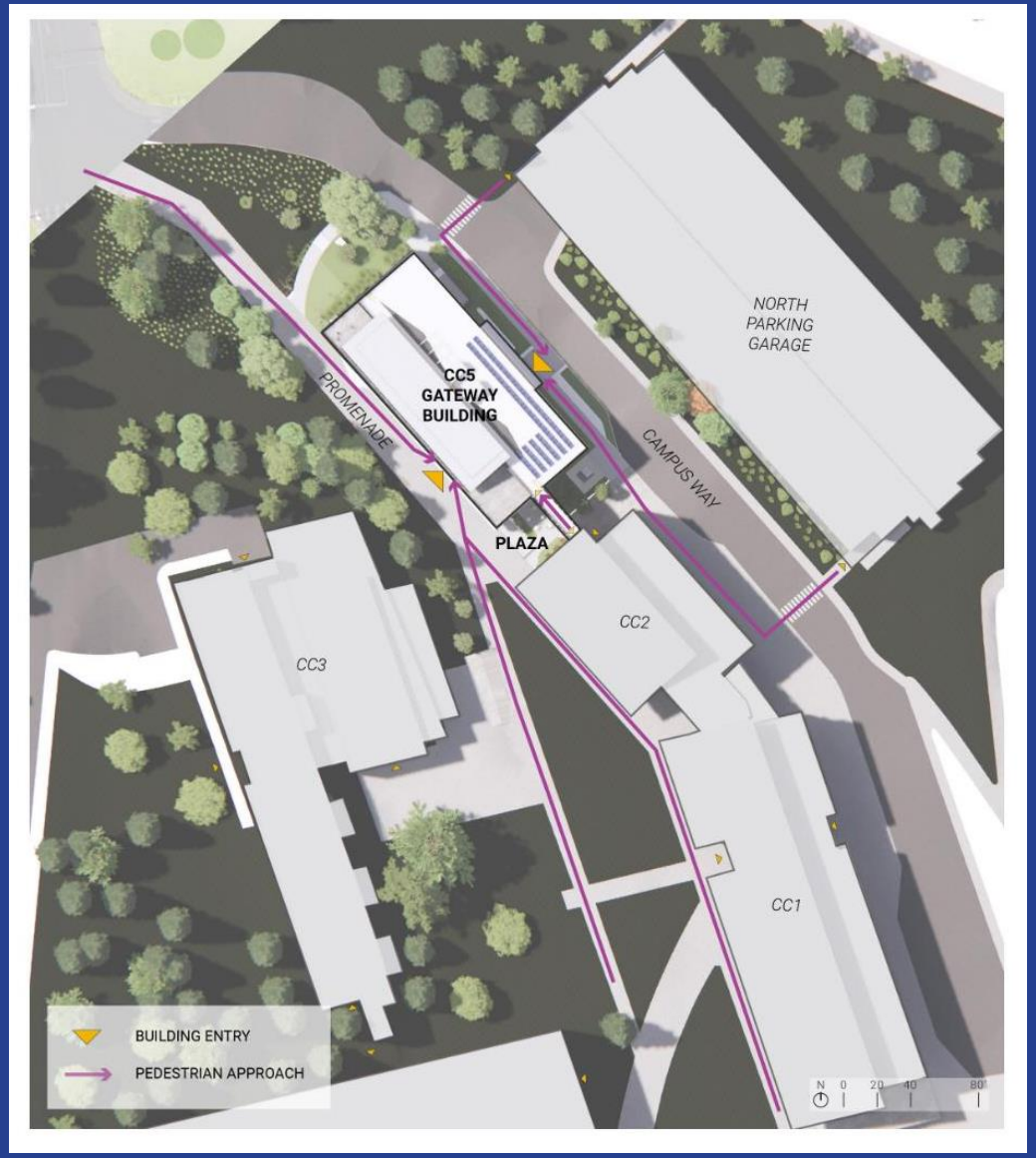
Site Design

Entries

- Campus Way Entry at Lower Level
- Promenade Entry at Level 1
- Connection to CC2

Outdoor Plaza between CC2 & CC5

Bus stops are temporarily relocated and bus loop becomes landscaping.



Program | Planning Principles

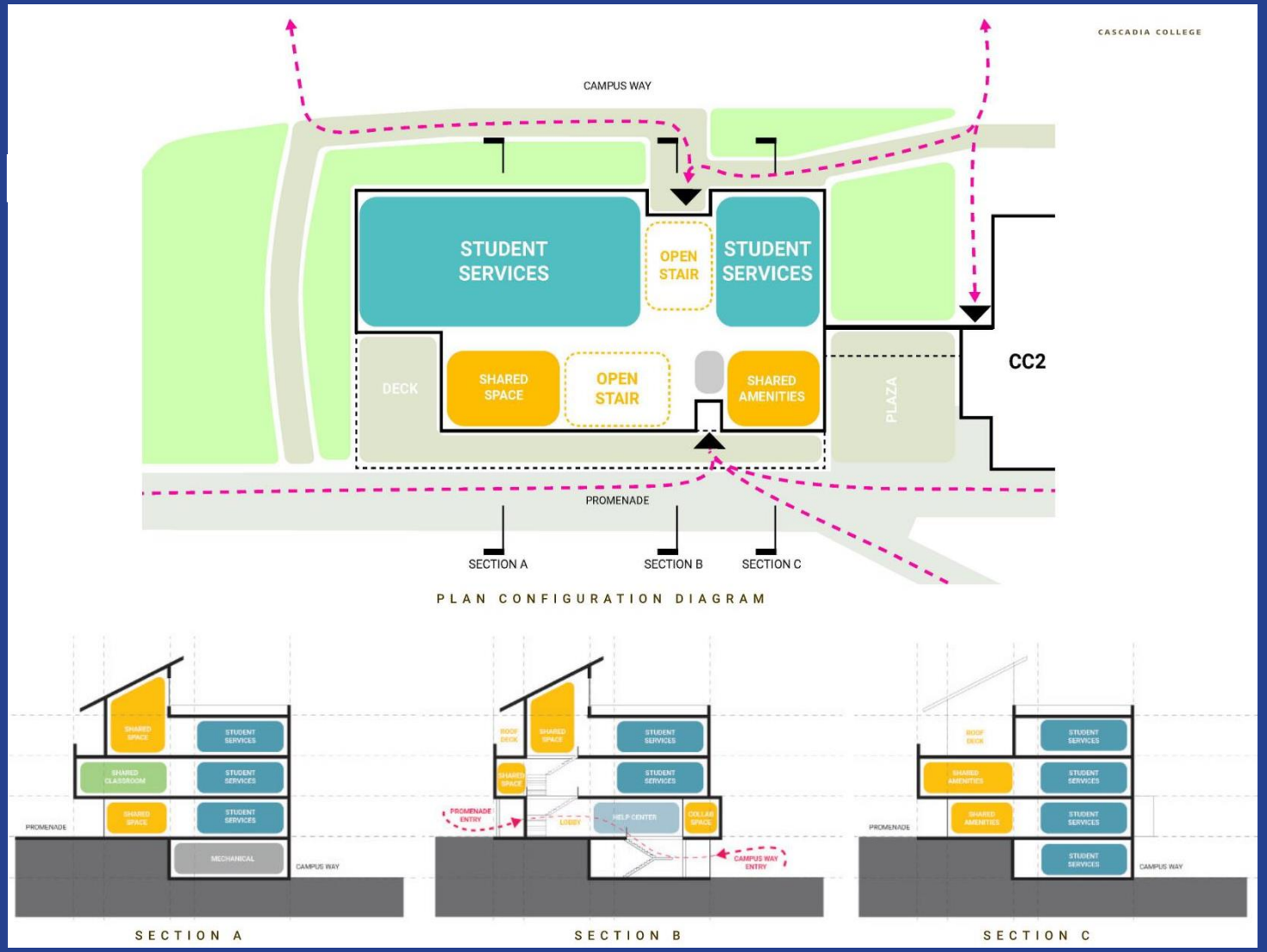
Student Services on Campus Way

- Offices and meeting rooms

Student Amenities on Promenade

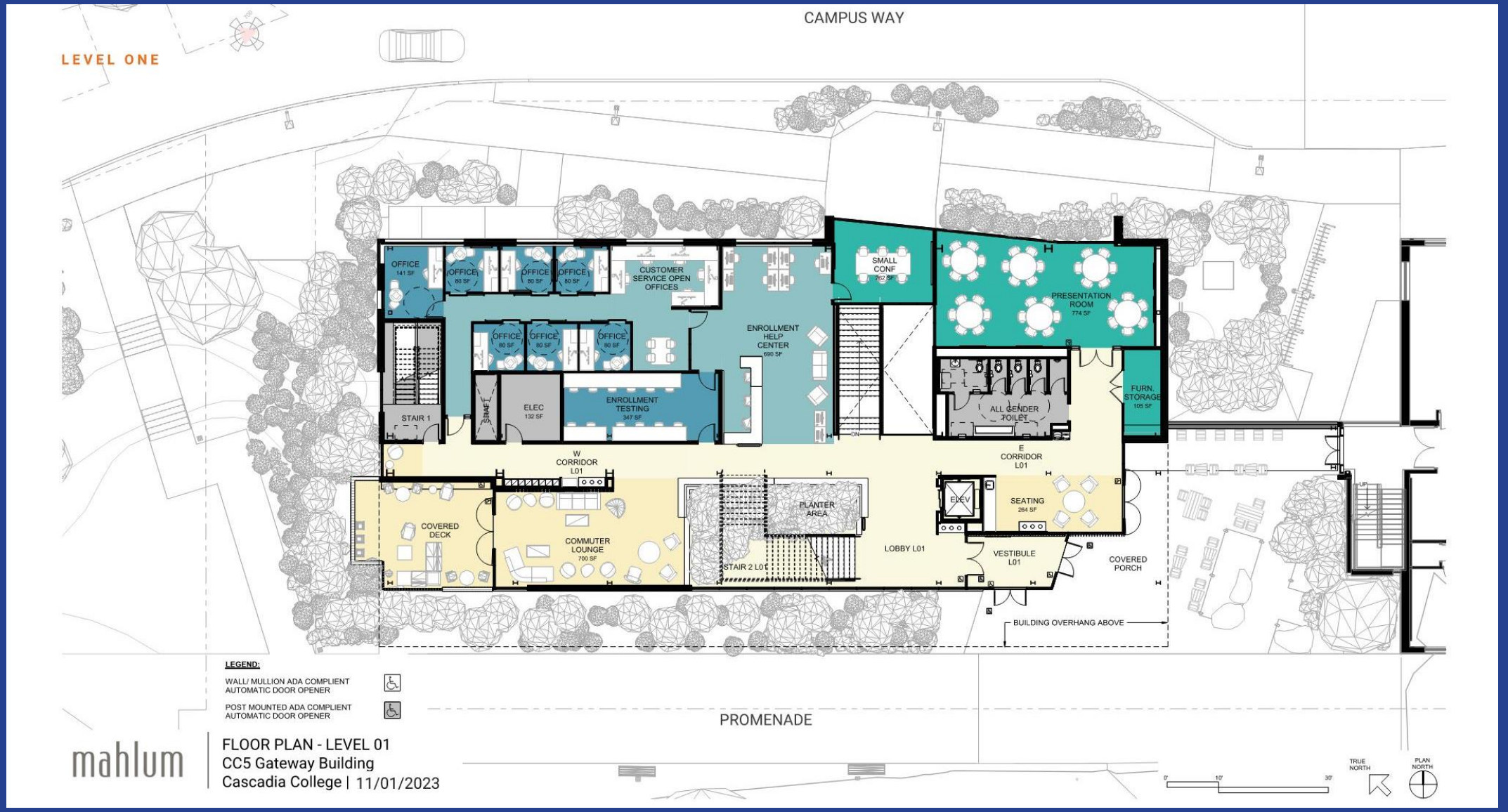
- Lounges & Study rooms
- Classrooms & Large meeting rooms

Open Stairs connect everything



Floor Plans – Lower Level

Floor Plans – Level 1



Floor Plans – Level 2

LEVEL TWO

LEGEND:

WALL/ MULLION ADA COMPLIENT AUTOMATIC DOOR OPENER

POST MOUNTED ADA COMPLIENT AUTOMATIC DOOR OPENER

mahlum

FLOOR PLAN - LEVEL 02
CC5 Gateway Building
Cascadia College | 11/01/2023

TRUE NORTH

PLAN NORTH

Floor Plans – Level 3

LEVEL THREE

LEGEND:

WALL/ MULLION ADA COMPLIENT AUTOMATIC DOOR OPENER

POST MOUNTED ADA COMPLIENT AUTOMATIC DOOR OPENER

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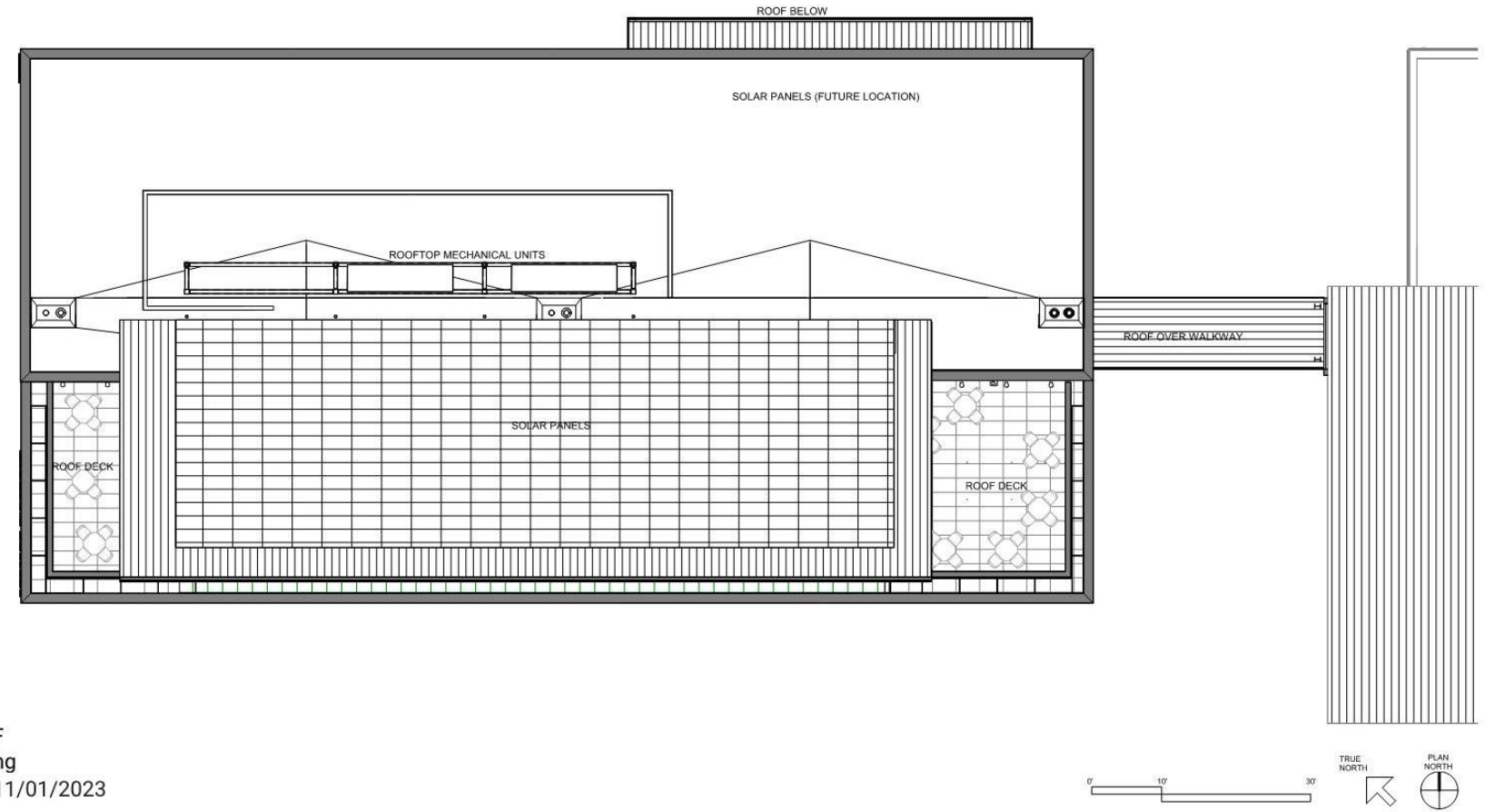
FLOOR PLAN - LEVEL 03
CC5 Gateway Building
Cascadia College | 11/01/2023

Roof Plan

ROOF PLAN



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FLOOR PLAN - ROOF
CC5 Gateway Building
Cascadia College | 11/01/2023

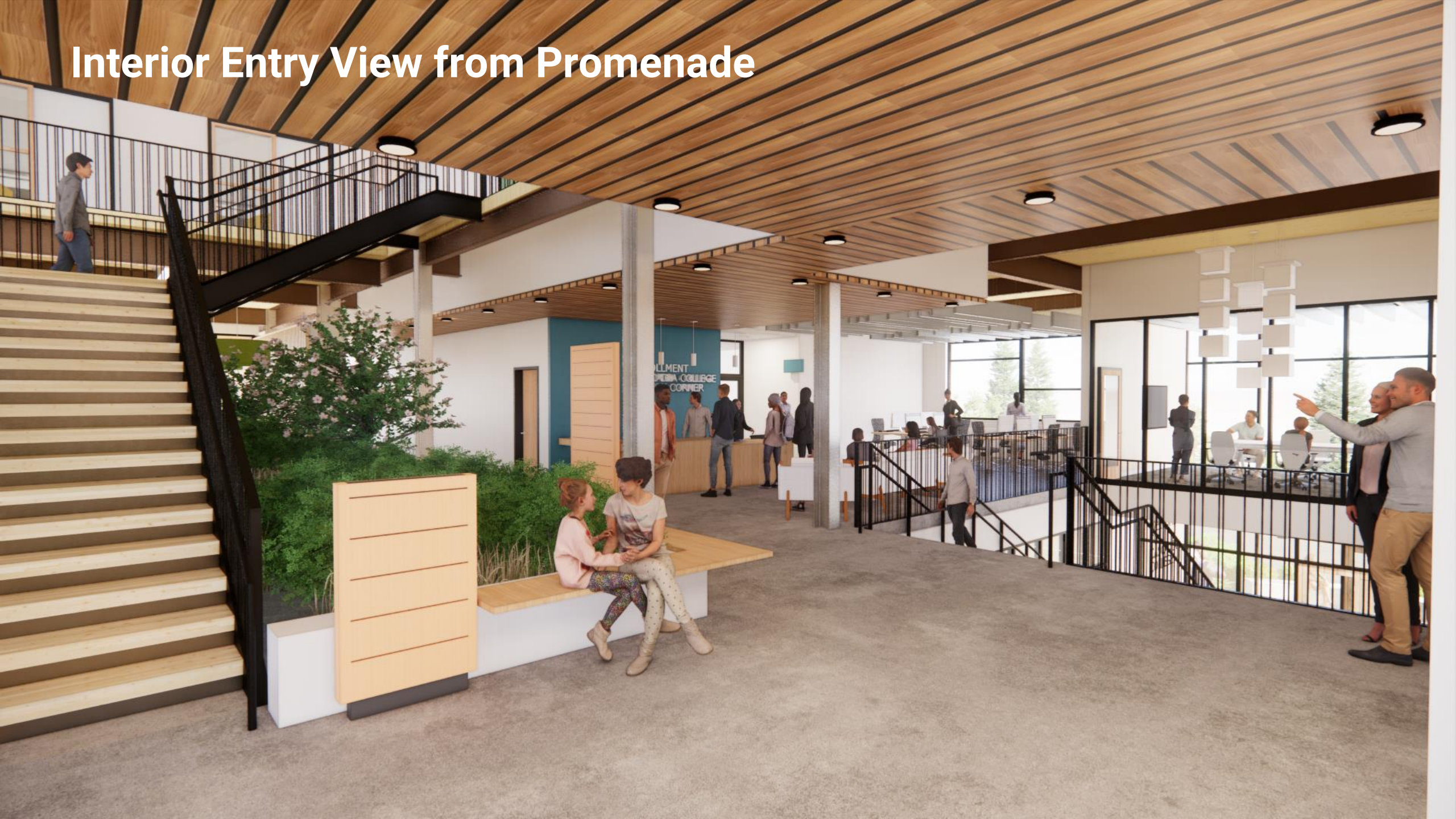
View from Promenade - North

View from Promenade - South

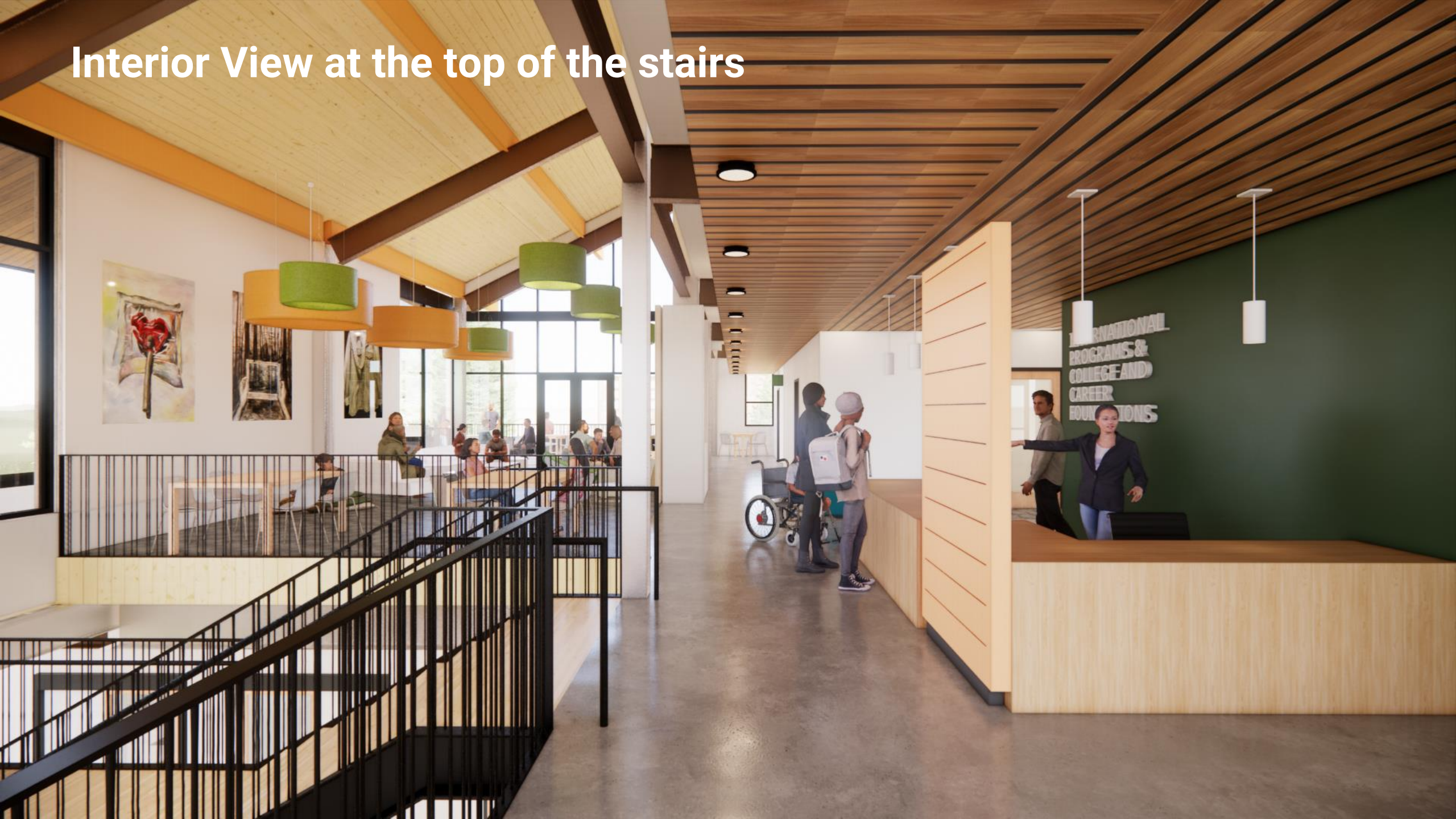
View from Campus Way - South

Interior Entry View from Campus Way

Interior Entry View from Promenade



Interior View at the top of the stairs



Building Systems Overview – Structure & Mechanical | Plumbing

Structural systems:

- 4 story building
- 3 stories of steel framing and CLT floors
- Concrete podium basement
- Glulam beams at vaulted sloped roof
- Lateral system are moment frames and brace frames

Mechanical & Plumbing systems:

- electric hybrid air to water heat pump water heater for heating water
- supplemental electric boiler
- space conditioning
  - DOAZ units for of each zone will be provided via terminal units with HW|CW
  - Trench fan coils at large windows
- Connection to Campus Chilled Water system

Building Systems Overview - Electrical

Power:

- Reduce the need for electrical room floor plan space with Centralized transformers and distribution boards in main electrical room.
- Electrical load types are segregated to increase power quality and meet the requirements of the WSEC.
- Power monitoring is incorporated to provide feedback on building system power consumption and opportunities to identify modifications to maximize building efficiency.
- 30kW photovoltaic array provided on the roof structure.
- space specific illumination needs and occupancy control

Telecommunications system:

- Structured cabling system to support Wide Area Network (WAN) and Local Area Network (LAN) transport of voice (analog and Voice-Over-IP), data, wireless and streaming video applications for a common cabling and network infrastructure.
- Networking equipment will be provided by the Owner such as servers, Ethernet switches, routers, network software, computers, and phones.
- Campus standard voice annunciation type fire alarm and alerting system
- Emergency Responders Radio Communications connected to the campus amplifier.

- Electrical on Lower Level & Level 3 and IT is on Level 1 & 2

Building Systems Overview - Site

Significant site improvements:

- construction of the facility's stormwater retention and filtration vaults
- New campus promenade for new grading and lighting
- coordination of closely adjacent utilities along Campus way
- Coordination of replacement of the existing transformer

Site logistics:

- require coordination with campus operations
- take into consideration of existing fire truck, parking and pedestrian circulation pathways
- exiting from CC2
- coordination of the timing and removal of the adjacent bus loop.

Request for Qualifications & Proposal for GC/CM Services

GC/CM Selection Process Schedule

DATE	
April 24, 2024	First publication of Request for Qualifications & Proposal (RFQ/RFP) for GC/CM Services
April 29, 2024	Project Informational Meeting (see Section 6.0) **10:00 AM PT, Room 260, Building CC2, site walk to follow at 11:00 AM PT**
May 13, 2024	**PHASE One:** statements of qualification submittal **due 2:00 PM PT**
May 24, 2024	Selection and notification of Finalist firms (short list) to move forward to **Phase Two.**
June 7, 2024	**Phase Two: Performance Evaluation** forms due from Finalists **by 2:00 PM PT**
June 10, 2024	**Phase Two: Proprietary Meetings** In Person at Cascadia College (location provided with notification to Finalists) – 3 finalists will be selected
June 20, 2024	**Phase Two: Interviews** – In Person at Cascadia College location provided with Phase Two Notification
June 24, 2024	**Phase Three: Final Proposal** (Bid) **Due June 24, 2024** before 2:00 PM PT submittal deadline
June 24, 2024	**Open bids on June 24, 2024 at 3:00 PM PT**. Final selection of firm with the highest score and best price.
June 25, 2024	Notification of successful and unsuccessful firms
July 9, 2024	Preconstruction Work Plan due
July 30, 2024	Contract for Preconstruction Services executed
August 12, 2024	Start – potholing scheduled for this week, must be completed prior to August 30, 2024

SCHEDULES

The following is the current planned project schedule.

Anticipated Construction Documents Completion, Permits, Construction Schedule

	Schematic Design – COMPLETED
	Design Development – COMPLETED
August 2024 – December 2024	Construction Documents**
June 2025	Building Permits
July 2025	Bid & Award Subcontracts**
August 2025	Start Construction**
January 2027	Substantial Completion
February/March 2027	Punch list and final commissioning
April 2027	Final Acceptance

Request for Qualifications & Proposal for GC/CM Services

PHASE ONE - RFQ

Criteria	Points
Bonding, Phase One Requirement (mandatory requirement)	Not Scored
Experience and technical competence of key professional personnel	20
Approach to Executing the Project / Preconstruction Services	20
Past Performance in negotiated and similarly complex projects such as active college campus or comparable pedestrian environment	15
Project scheduling & cost control	10
The proposer's capacity to perform the work	5
Risk Identification and Analysis	10
Value Engineering and Constructability Analysis	10
Proximity of Firm to Project Location / Self Performance	5
Sustainable environmental and LEED experience	5
The proposers past performance in utilization of disadvantaged business enterprises, small business entities and their inclusion plan for these entities.	0
Total	100

PHASE TWO - INTERVIEW

Criteria	Value
Ability and qualification of professional personnel	15
Risk analysis, mitigation and management	10
Value engineering, constructability/interdisciplinary review and approach to executing the project	20
Approach to Preconstruction Services, integration with design team, and cost estimating	20
Time and budget requirements; schedule management	20
Past performance on similar complex or negotiated contracts	10
Final Proposal (Bid)	5
Diverse Business Inclusion Plan (Mandatory Requirement)	Not Scored
Accident Prevention Program (Mandatory Requirement)	Not Scored

Request for Qualifications & Proposal for GC/CM Services

The GC/CM shall provide CM services, including but not limited to:

- Assistance in identifying safe work practices and requirements for construction.
- Assessing and recommending site logistics requirements.
- Recommending phasing, sequencing of work and construction scheduling.
- Providing cost-estimating including MACC Negotiated Support Services budgeting. Confirm budget alignment.
- Determining and reconciling constructability issues and performing constructability analysis of the design documents prior to subcontract bidding.
- Assessing alternative construction options for cost savings.
- Identifying products for Value Engineering (VE) and engineering systems for life cycle cost design considerations and recommending all work necessary to support their implementation.
- Participating in for Owner's design and construction document phase coordination reviews.
- Prepare subcontract bid packages and manage the bidding process.
- Provide utility investigative services/potholing (early August 2024) for design team use.

Questions & Answers

(Please sign in: Name, E-mail, phone number)

PART 1 GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.02 WORK RELATED IN OTHER SECTIONS

A. Section 230500: Basic HVAC Materials and Methods.

B. Section 230900: Building Automation System (BAS) Controls.

C. Section 232113: Hydronic Piping, Valves and Specialties.

D. Section 233113: Air Distribution.

E. Division 26: Electrical.

1.03 SUMMARY

A. Scope: Extent of testing, adjusting and balancing work required by this Section is indicated on the drawings, in schedules, and by the requirements of this Section, and Section 230500 -Basic Mechanical Requirements.

B. Systems: Testing, adjusting and balancing specified in this Section shall include, but not be limited to, the following systems:
   1. Air handling systems including supply, return and exhaust.
   2. Air distribution ductwork including supply, return and exhaust.
   3. Dedicated exhaust systems.
   4. Building automation system controls.
   5. Hydronic system including heating, chilled water and condenser water.
   6. Steam distribution.
   7. Smoke control system.
   8. Underfloor air distribution system air leakage.
   9. Instruction of Owner's personnel for future balancing of systems.

1.04 CODES AND STANDARDS

A. The Contractor is cautioned that code requirements not explicitly detailed in these specifications or drawings, but which may be reasonably inferred or implied from the nature of the project, must be provided as part of the contract.

B. Reference Standards
   1. ANSI/ASHRAE Standard 111 - Measurement, Testing, Adjusting and Balancing of Building HVAC Systems (current edition).
   2. ASHRAE - HVAC Applications Handbook: Chapter 38 - Testing, Adjusting and Balancing (current edition).
   3. ASHRAE 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings, Chapter 6 (current edition).
   4. AABC - National Standards for Total System Balance.
   5. NEBB - Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.
   6. SMACNA - HVAC Systems-Testing, Adjusting and Balancing.
   7. SMACNA - HVAC Air Duct Leakage Test Manual.
   8. ANSI - American National Standards Institute. Comply with the following:
      a. S1.4: Specifications for Sound Level Meters.
      b. S1.11: Specifications for Electroacoustics - Octave-Band and Fractional-Octave-Band Filters
   9. Building Code, with State Amendments, Chapter 9 Fire Protection Systems.
   10. Mechanical Code, with State Amendments, Chapter 4 Ventilation Air Supply.

11. Local Nonresidential Energy Code.

1.05 QUALITY ASSURANCE

A. Contractor's Qualifications: A specialist certified by the National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC) with at least 5 years of experience in those testing, adjusting and balancing requirements similar to those required for this project, is not the installer of the system to be tested and is otherwise independent of the project. Testing, adjusting, and balancing shall be performed by a certified NEBB technician or a certified AABC technician under direct field supervision of a Certified NEBB Supervisor or a Certified AABC Supervisor. Testing and balancing agency must submit qualifications for review and approval prior to acceptance for work.

B. Penalty: The Contractor shall submit the name of the organization he proposes to employ for approval within 30 days after contract award. If the Contractor fails to submit the name of an acceptable agency within the specified time, a firm may be selected to accomplish the work, and this selection shall be binding upon the Contractor at no additional cost.

C. Retainages: In addition to any other sums retained or withheld pursuant to the provisions of this Contract, the amount of dollars will be withheld from payments to the contractor until such time as the work has been completed and accepted. In no event will this amount be paid to the Contractor prior to 60 days following acceptance of the project; during such time, the Contractor shall investigate and correct any reported deficiencies unless such deficiencies are a result of unauthorized tampering by building occupants.

D. Calibration of Testing Instruments: All measurement instruments used for testing, adjusting, balancing, and commissioning shall be calibrated. The time between the most recent calibration data and the final test report date shall not be over 6 months.

E. Testing and balancing agency, as part of its contract, shall act as authorized inspection agency responsible to Consulting Engineer and Owner, and shall list all items that are installed incorrectly, require correction, or have not been installed in accordance with contract Drawings and Specifications, pertaining to air distribution, cooling and heating systems. The testing and balancing agency is required to provide written reports of all deficiencies and proposed recommendations to the Owner' Representative, Contractor, Architect and Engineer.

F. The testing and balancing agency shall provide with their bid a performance guarantee covering all phases of the work as herein specified.

G. The General and Mechanical Contractors shall cooperate with the selected testing and balancing agency in the following manner:
   1. Provide sufficient time before final completion dates so that tests and balancing can be accomplished.
   2. The various system installers, suppliers and contractors shall provide all required materials, labor and tools to make corrections when required without undue delay. Install balancing dampers and valves as required by testing and balancing agency.
   3. The contractor shall put all heating, ventilating and air conditioning systems and equipment into full operation and shall continue the operation of the same during each working day of testing and balancing.
   4. Testing and balancing agency shall be kept informed of any major changes made to the system during construction, and shall be provided with a complete set of Record Drawings.
   5. The General Contractor shall make space and other facilities available to the testing and balancing agency to enable their work to progress. The General Contractor shall schedule the work of other trades to avoid conflicts with this work.

H. All air balancing work shall be coordinated with other disciplines to comply with the meet or exceed the minimum requirements of the Americans with Disabilities Act (ADA), Building Code, local amendments and State Energy Code.

1.06 SUBMITTALS

A. Conform to the Submittals requirements of Division 01.

B. Forms: The Contractor shall deliver a complete copy of either NEBB or AABC standard forms for testing and balancing work associated with the project. These forms shall serve as specific guidelines for producing final test report. Hybrid or non-standards forms are not acceptable.

C. Test Reports: Provide final certified test report, six (6) certified hard copies or one electronic PDF formatted copy, with signature of the test and balance supervisor responsible for the work. The final reports shall include key plans identifying all inlets and outlets. Final test reports shall be typed. Reports with handwritten data entry are not acceptable.

D. Maintenance Data: Include, in maintenance manuals, copies of certified and approved test and balance reports and identification of instruments.

E. Qualifications: The Test and Balance Agency shall submit qualifications of all persons responsible for supervising and performing the on-site testing and balancing work and the name of the certifying agency, NEBB or AABC. Provide a reference list of five (5) similar size projects with contact person and telephone number.

F. LEED:
   1. Air-Balance Report for Prerequisite EQp1: Documentation of work performed per ASHRAE 2.1, Section 7.2.2 - "Air Balancing".
   2. TAB Report for Prerequisite EAc2: Documentation of work performed per ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing".

1.07 AGENDA

A. Agenda: A preliminary report and agenda shall be submitted and approved prior to the start of testing and balancing work.
   1. Review plans and specifications prior to installation of any of the affected systems, and submit a report indicating any deficiencies in the systems that would preclude the proper adjusting, balancing, and testing of the systems.
   2. The agenda shall include a general description of each air and water system with its associated equipment and operation cycles for heating and cooling.
   3. The agenda shall include a list of all air and water flows to be performed at all mechanical equipment.
   4. The agenda shall incorporate the proposed selection points for sound measurements, including typical spaces as well as sound sensitive areas such as conference rooms.
   5. The agenda shall also include specific test procedures and parameters for determining specified quantities (e.g. flow, drafts, sound levels) from the actual field measurements to establish compliance with contract requirements. Samples of forms showing application of procedures and calculations to typical systems shall be submitted.
   6. Specific test procedures for measuring air quantities at terminals shall specify type of instrument to be used, method of instrument application (by sketch) and factors for:
      a. Air terminal configuration.
      b. Flow direction (supply or exhaust).
      c. Velocity corrections.
      d. Effective area applicable to each size and type of air terminal.
      e. Density corrections.
   7. The agenda shall include identification and types of measurement instruments to be used, and their most recent calibration date.

1.08 JOB CONDITIONS

A. General: Do not proceed with testing, adjusting and balancing work until the following conditions have been met.

1. Installation and start-up work on equipment or systems to be tested has been completed and documented.
2. Work area scheduled for testing, adjusting and balancing is clean and free from debris, dirt and discarded building materials.
3. All architectural openings (doors, windows, and other openings) which may affect the operation of the system to be tested shall be in their completed normal positions and operation.
4. All related mechanical systems which may affect the operation of the system to be tested shall be at their normal operating conditions.

PART 2 PRODUCTS

2.01 TEST HOLES

A. Test holes and ports shall be provided in ducts, housings and pipes as directed by the Balancing Agency. At each location where ducts or plenums are insulated, test holes shall be provided with an approved extension with plug fitting.

2.02 PATCHING MATERIALS

A. Material: Seal, patch and repair ductwork, piping and equipment drilled or cut for testing purposes.
   1. Plastic plugs with retainers may be used to patch drilled holes in ductwork and housings.
   2. Insulation shall be neatly hemmed with metal or plastic edging, leaving test points visible for future testing.

2.03 TEST INSTRUMENTS

A. Test Instruments: All instruments used for measurements shall be accurate and calibration histories for each instrument shall be available for examination. Each test instrument shall be calibrated by an approved laboratory or by the manufacturer. The Owner's Representative has the right to request instrument recalibration, or the use of other instruments and test methodology, where accuracy of readings is questionable.

B. Additional Instruments: Permanently installed measuring instruments, such as temperature and pressure gauges, shall be checked against Certified Calibrated instruments. Any instrument which does not meet specification requirement shall be replaced or recalibrated.

C. Cone Instruments: The Contractor shall employ manufactured enclosure type cones, capable of air volume direct readings, for all diffuser/grille/register air flow measurements. The readout meters shall meet calibration requirements.

PART 3 EXECUTION

3.01 PROCEDURES AND INSTRUMENTS, GENERAL

A. Requirements: All systems and components thereof shall be adjusted to perform as required by approved project drawings and specifications.

B. Test Duration: Operating tests of heating and cooling coils, fans, and other equipment shall be of not less than four-hours duration after stabilized operating conditions have been established. Capacities shall be based on temperatures and air and water quantities measured during such tests.

C. Instrumentation: Method of application of instrumentation shall be in accordance with the approved agenda.
   1. All instruments shall be applied in accordance with the manufacturer's certified instructions.
   2. All labor, instruments, and appliances required shall be furnished by the Contractor. Permanently installed instruments used for the tests (e.g., flow meters and Btu meters) shall not be installed until the entire system has been cleaned and ready for operation.

3.02 DUCT SMOKE DETECTORS

A. Duct smoke detectors shall be provided and located as required by these specifications and drawings and as required by the building codes and the following:

1. Obtain information from the Contractor who is to furnish the smoke detectors on the proper device placement and installation limitations and on the proper differential pressure across the sampling tubes of the duct detectors and for required air velocity range requirements.
2. Installing Contractor shall review the manufacturer's installation guidelines for proper mounting locations.
3. The testing and balancing agency shall be engaged to confirm that proposed mounting locations will not be adversely impacted by airflows.

B. Duct smoke detectors shall be tested in collaboration with the installing Contractor and project Fire Alarm Contractor to ensure proper air flow sampling and differential pressure.

3.03 DUCTWORK AIR LEAKAGE TESTING

A. Dust leakage testing is required on all ductwork constructed to 4” wg class and higher.

B. Test and balance agency shall perform active air flow testing of ductwork systems or sections of ductworks. Agency shall inspect and confirm that all ductwork is sealed per the specification requirements prior to performing any testing. Calculate maximum allowable air leakage by system based on total design air flow rate and/or square footage of ductwork. Maximum allowable system air flow leakage shall not exceed 5% of total air volume, or the maximum allowable per local energy or mechanical codes where the allowable limit is less than 5%.

C. Representative sections totaling 10 percent, or greater, of the total installed duct area shall be tested. Where the tested 10 percent fails to comply with the requirements, then 40 percent of the total installed duct area shall be tested. Where the tested 40 percent fails to comply then 100 percent of the total installed duct area shall be tested and verified to have a leakage rate that does not exceed the maximum allowable limit. Duct sections shall be selected by the Owner’s Representative. Obtain total duct surface area and air flow volumes for each duct section from the installing contractor. Positive pressure leakage testing shall be permitted for negative pressure ductwork.

D. Additional ductwork leakage testing may be required to meet local energy and mechanical code requirements. Refer to local codes for applicability and requirements.

E. Ductwork systems to be leakage tested and procedures shall include:
1. Testing shall be performed at 1.5 times the peak design outlet static pressure (external static pressure) from the air handling unit/fan, but not greater than the maximum SMACNA pressure rating of the ductwork construction classification.
2. Testing is not required of flexible ductwork or ductwork downstream of VAV terminal units.
3. Leakage through manufactured products, such as air handling units, dampers, fire/smoke dampers and terminal units may be excluded from the leakage calculations based on manufacturer stated values, at pressure, or these units may be temporarily sealed with painter’s tape or plastic sheeting during testing to seal any openings and must be removed after testing.
4. Supply air ductwork from the outlet of the air handling unit/fan to inlet side of terminal units or connection to flexible ductwork. Duct leakage testing is not required downstream of terminal units.
5. All supply, return and exhaust air ductwork located outside the building envelope.
6. Return and exhaust air ductwork located in unconditioned spaces from inlet of the air handling unit/fan to the ductwork terminations upstream of each return air grille.
7. Laboratory and fume hood exhaust air ductwork from inlet of the air handling unit/fan to the connection at the remote exhaust air grille or fume hood connection.
8. Kitchen exhaust air ductwork from inlet of the exhaust fan to the connection at the remote exhaust hood.

F. For buildings under the jurisdiction of the UMC or CMC provide duct leakage testing in compliance with maximum allowable leakage quantities per code Section 603 and in no case greater than 5% of the total system air flow volume. Ductwork shall be leak-tested in accordance with the procedures described in SMACNA HVAC Air Duct Leakage Test Manual. The permitted duct leakage shall be not more than the following:

1. $L_{MAX} = C_L P^{0.65}$ where:
   a. L_{MAX}=maximum permitted leakage (ft^3/min/100 sf [0.0001 (m^3/s)/m^2] duct surface area.
   b. $C_{L=}$ Six (6), SMACNA duct leakage class (ft^3/min/100 sf [0.0001 (m^3/s)/m^2] duct surface area at 1 inch water column (0.2 kPa).
   c. P=test pressure, which shall be equal to the design duct pressure class rating in inches of water column (kPa).

G. Additional leakage testing in California, per the energy code, requires that duct systems shall be sealed to a leakage rate not to exceed 6% of the fan flow if the duct systems are:
   1. Connect to a constant volume, single zone system, air conditioners, heat pumps or furnaces, and,
   2. Serve less than 5,000 square feet of floor area, and
   3. Have more than 25% duct surface area located in one or more of the following places:
      a. Outdoors, or,
      b. In a space directly under a floor where the U-factor of the roof is greater than the U-factor of the ceiling, or,
      c. In a space directly under a roof with fixed vents or openings to the outside or unconditioned spaces, or,
      d. In an unconditioned crawlspace, or,
      e. In other unconditioned spaces.

H. Ductwork installer shall prepare ductwork for pressure testing as deemed appropriate to maintain construction schedule. Ductwork may be tested as total systems or in sections. Sectional testing will require documentation to prove the totalized system leakage is within allowable range of entire system. Ductwork inlets and outlets may be temporarily sealed airtight with plastic, or other means, to facilitate testing pressures.

I. Testing may occur through ductwork devices such as balancing dampers, smoke fire dampers and coils. Manufacturer provided air leakage allowances for such devices may be excluded from duct leakage measurement but must be documented in final report.

J. The leakage rate shall be confirmed through field verification and diagnostic testing in accordance with procedures defined by Oriflow Air Leakage Test, or equivalent procedure. Perform all testing utilizing a duct leakage testing system, Oriflow Duct Leakage Tester or equal, with calibrated fan, orifice, gauges, ductwork, pressure tips and tubing.

3.04 AIR SYSTEM PROCEDURES

A. Adjustments: Adjust all air handling systems to provide design air quantity to or through, each component, and to maintain stable and comfortable interior temperatures, free of drafts or stagnant air conditions.

B. Equalizers: Equalizing devices shall be adjusted to provide uniform velocity across the inlets (duct side for supply) of terminals prior to measuring flow rates.

C. Balance: Flow adjusting (volume control) devices shall be used to balance air quantities (i.e., proportion flow between various terminals comprising system) to the extent that their adjustments do not create objectionable air motion or sound (i.e., in excess of specified limits).
   1. Balancing between runs (submains, branch mains, and branches) generally shall be accomplished by flow regulating devices at, or in, the divided-flow fitting.
   2. Restriction imposed by flow regulating devices in or at terminals shall be minimal.
   3. Final measurements of air quality shall be made after the air terminal has been adjusted to provide the optimum air pattern of diffusion and as indicated on the air distribution drawings.

D. Fan Adjustment: Total air system quantities, generally, shall be varied by adjustment of fan speeds or axial-flow fan wheel blade pitch. Damper restriction of a system's total flow may be used only for systems with direct-connected fans (without adjustable pitch blades), provided system pressure is less than 0.5” w.g. and sound level criteria are met.

E. Air Measurement: Where air quantity measuring devices are specified in other sections such systems shall be used as a cross-check of portable measuring equipment.
   1. Except as specifically indicated herein, pitot tube traverses shall be made of each duct to measure air flow therein. Pitot tubes, associated instruments, traverses, and techniques shall conform to the ASHRAE "Handbook Fundamentals Inch Pound Edition."
   2. For ducts serving modular office areas with movable partitions, which are subject to change, pitot tube traverses may be omitted provided the duct serves only a single room or space and its design volume is less than 2000 cfm. In lieu of pitot tube traverses, airflow in the duct shall be determined by totaling volume of individual terminals served, measured as described herein.
   3. Where duct's design velocity and air quantity are both less than 1000 (fpm/cfm), air quantity may be determined by measurements at terminals served.

F. Test Holes: Test holes shall be in a straight duct, as far as possible downstream from elbows, bends, take-offs, and other turbulence generating devices, to optimize reliability of flow measurements.

G. Air Terminal Balancing: Generally, measurement of flow rates by means of velocity meters applied to individual terminals, with or without cones or other adapters, shall be used only for balancing. Measurement of air quantities at each type of air terminal (inlet and outlet) shall be determined by the method approved for the balancing agenda. Laboratory tests shall be conducted to prove accuracy of testing methodology and test data when so directed. Such tests shall be conducted in conformance with applicable ASHRAE or American Society of Mechanical Engineers (ASME) codes and shall be performed at no additional cost to Owner.

H. Air Motion: Air motion and distribution shall be as specified and indicated on drawings. The Contractor, at no additional cost to the Owner shall, in addition to air motion and direct measurements, perform smoke tests as requested to demonstrate the air distribution and pattern from air terminals and outlets.

I. Air system test and balance procedures shall include, but not be limited to the following requirements:
   1. Test and adjust blower RPM to design requirements.
   2. Test and record motor full load amperes.
   3. Make pitot tube traverse of main supply ducts and obtain design CFM at fans.
   4. Test and record system static pressures, suction pressure directly at system fan inlet, and outlet pressure directly at system fan outlet or discharge. Test and record static pressure across each component of air handling system (coils, filters, etc.).
   5. Test and adjust system for design CFM recirculated air.
   6. Test and adjust system for design CFM outside air.
   7. Test and record entering air temperatures.
   8. Test and record leaving air temperatures.
   9. Adjust all supply, return and exhaust air ducts to proper design CFM.
   10. Adjust all zones to proper design CFM, supply and return.
   11. Test and adjust duct systems and each diffuser, grille, and/or register to within 10% of design requirements.
   12. Each grille, diffuser and register shall be identified as to location and area.
   13. Operate each variable frequency drive (VFD) and verify controls installation is complete.
   14. Size, type and manufacturer of VAV boxes, diffusers, grilles, registers and all tested equipment shall be identified and listed. Manufacturer's ratings on all equipment shall be used to make required calculations.
   15. Readings and tests of diffusers, grilles and registers shall include required FPM velocity and test resultant velocity, required CFM and test resultant CFM after adjustment.
   16. In cooperation with the control manufacturer's representative, setting adjustments of automatically operated dampers to operate as specified, indicated, and/or noted. Testing agency shall check all controls requiring adjustment by control installers. Room thermostats shall be checked for cooling and heating response.
   17. All diffusers, grilles and registers shall be adjusted to minimize drafts in all areas.

18. Adjust overall system balances to allow all self-closing exterior doors to close from any open position. Maximum interior air pressure in all operational modes shall not exceed 0.05" static pressure relative to the outside air pressure. Comply with chapter 10 of the Building Code to assure that self-closing doors will release with a maximum force of 15 pounds.
19. As part of the work of this contract, the HVAC contractor shall make any changes in the pulleys, belts and dampers or the addition of dampers required for correct balance as recommended by air balance agency, at no additional cost to Owner.
20. After air balancing is completed and RPM determined, HVAC Contractor shall provide fixed pitch pulleys.
21. All mixing boxes, VAV air valves, control dampers, smoke dampers and similar devices which operate at 100% shut off shall be tested for leakage.
22. Variable Air Volume Fan Systems: The primary balancing mode is 100% outside air with all terminal boxes on a full call for cooling. Also check and record performance at minimum outside air with all terminal boxes on call for full cooling and at minimum outside air with all terminal boxes on call for full heating and at minimum outside air in the deadband range with no call for heating or cooling. Verify that the systems are operating on a stable part of the fan curves in each mode. Record final duct static controller settings.
23. Provide testing of underfloor air distribution plenum floor mock-ups and final floor installation to document that plenum does not exceed 5% air leakage rate at maximum 0.10” w.g. positive differential pressure.
24. Laboratory Fume Hood Procedure:
    a. Before performing laboratory fume hood testing, measure, adjust and record the supply airflow and airflow patterns of each supply air outlet that is located in the same room as the hood. Adjust the air outlet flow pattern to minimize turbulence and to achieve the desired airflow patterns at the face and inside the hood. Verify that adequate makeup air is available to achieve the indicated flow of the hood.
    b. Measure, adjust, and record the airflow of each laboratory fume hood by duct Pitot-tube traverse with the laboratory fume hood sash in the design open position.
        1) For laboratory fume hoods installed in variable exhaust systems, measure, adjust, and record the hood exhaust airflow at maximum and at minimum airflow conditions.
    c. Adjust the damper controller to obtain the indicated exhaust airflow.
    d. After balancing is complete, do the following:
        1) Measure and record the static pressure at the hood duct connection with the hood operating at indicated airflow.
        2) Measure and record the face velocity across the open sash face area. Measure the face velocity at each point in a grid pattern. Perform measurements at a maximum of 12 inches (300 mm) between points and between any point and the perimeter of the opening.
            (a) For laboratory fume hoods designed to maintain a constant face velocity at varying sash positions, also measure and record the face velocity at 50 and 25 percent of the design open sash position.
            (b) Calculate and report the average face velocity by averaging all velocity measurements.
            (c) Calculate and report the exhaust airflow by multiplying the calculated average face velocity by the sash open area. Compare this quantity with the exhaust airflow measured by duct Pitot-tube traverse. Report differences.
            (d) If the average face velocity is less than the indicated face velocity, retest the average face velocity and adjust hood baffles, fan drives, and other parts of the system to provide the indicated average face velocity.
        3) Check each laboratory fume hood for the capture and containment of smoke by using a hand-held emitting device. Observe the capture and containment of smoke flow pattern across the open face and inside the hood. Make adjustments necessary to achieve the desired results.

e. With the room and laboratory fume hoods operating at indicated conditions, perform an "as installed" performance test of the laboratory fume hood according to ASHRAE 110. Test each laboratory fume hood(s) and document the test results.

25. Space Pressurization Procedure:
    a. Before testing for space pressurization, observe the space to verify the integrity of the space boundaries. Verify that windows and doors are closed and applicable gaskets, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.
    b. Measure, adjust, and record the pressurization of each room, each zone, and each building by adjusting the supply, return, and exhaust airflows to achieve the indicated conditions.
    c. Measure space pressure differential where pressure is used as the design criteria and measure airflow differential where differential airflow is used as the design criteria for space pressurization.
        1) For pressure measurements, measure and record the pressure difference between the intended spaces at the door with all doors in the space closed. Record the high-pressure side, low-pressure side, and pressure difference between each adjacent space.
        2) For applications with cascading levels of space pressurization, begin in the most critical space and work to the least critical space.
        3) Test room pressurization first, then zones, and finish with building pressurization.
    d. To achieve indicated pressurization, set the supply airflow to the indicated conditions and adjust the exhaust and return airflow to achieve the indicated pressure or airflow difference.
    e. For spaces with pressurization being monitored and controlled automatically, observe and adjust the controls to achieve the desired set point.
        1) Compare the values of the measurements taken to the measured values of the control system instruments and report findings.
        2) Check the repeatability of the controls by successive tests designed to temporarily alter the ability to achieve space pressurization. Test over pressurization and under pressurization, and observe and report on the system's ability to revert to the set point.
        3) For spaces served by variable-air-volume supply and exhaust systems, measure space pressurization at indicated airflow and minimum airflow conditions.
    f. In spaces that employ multiple modes of operation, such as normal mode and emergency mode or occupied mode and unoccupied mode, measure, adjust, and record data for each operating mode.
    g. Record indicated conditions and corresponding initial and final measurements. Report deficiencies.

3.05 ADA COMPLIANCE

A. All air balancing work shall be coordinated with other disciplines to comply with meeting or exceeding the minimum requirements of the Americans with Disabilities Act (ADA), Building Code, State Energy Code and local amendments. Final air balancing for all systems in each space shall be verified and adjusted as necessary to meet the following requirements during peak ventilation, smoke control mode, partial ventilation and minimum ventilation modes during occupied and non-occupied hours. The following requirements are provided as consolidated list of minimum ADA requirements:
    1. The required force for pushing or pulling open a door other than fire doors shall not exceed 5 pounds.
    2. At fire doors the required opening force shall not exceed 15 pounds.
    3. At fire doors the doors shall be set in motion when subjected to a force not exceeding 30 pounds.
    4. At fire doors the doors shall swing to a full open position when subjected to a force not exceeding 15 pounds.
    5. The force to operate door latch releases shall not exceed 5 pounds.
    6. The differential pressure between the building lobby and outside shall remain positive between 0.01” w.g., minimum, and 0.05” w.g., maximum, during operational hours.

3.06 AIR SYSTEM DATA

A. Report: The certified report shall include for each air handling system the data listed below.
   1. Equipment (Fan or Factory Fabricated Station Unit):
      a. Installation data
         1) Manufacturer and model
         2) Size
         3) Arrangement, discharge and class
         4) Motor hp, voltage, phase, cycles, and full load amps
         5) Location and local identification data
      b. Design data
         1) Data listed in schedules on drawings and specifications.
      c. Fan recorded (test) data
         1) CFM
         2) Static pressure (suction and discharge, across each coil and filter set)
         3) RPM
         4) Motor operating amps
         5) Motor operating bhp
   2. Duct Systems:
      a. Duct air quantities (maximum and minimum) - main, submains, branches, outdoor (outside) air, total air, and exhaust:
         1) Duct size(s)
         2) Number of pitot tube (pressure measurements)
         3) Sum of velocity measurements (Note: Do not add pressure measurements)
         4) Average velocity
         5) Recorded (test) cfm
         6) Design cfm
      b. Individual air terminals
         1) Terminal identification supply or exhaust, location and number designation
         2) Type size, manufacturer and catalog identification applicable factor for application, velocity, area, etc., and designated area
         3) Design and recorded velocities - fpm (state "core," "inlet," etc., as applicable)
         4) Design and recorded quantities - cfm (deflector vane or diffusion cone settings)

3.07 WATER SYSTEM PROCEDURES

A. Preparation:
   1. Open all valves to fully open position. Close coil bypass stop valves. Set mixing valve to full coil flow.
   2. Remove all strainers and clean same. Reinstall.
   3. Examine water system and determine if water has been treated and cleaned.
   4. Check pump rotation.
   5. Check expansion tank to determine they are not air bound and the system is completely full of water.
   6. Check all air vents at high points of water systems and determine that all are installed and operating freely.
   7. Check operation of automatic bypass valve.
   8. Operate each variable frequency drive (VFD) and verify controls installation is complete.
   9. Check and set operating temperatures of all equipment at design requirements.
   10. Complete air balance must have been accomplished before actual water balance begins.

B. Adjustment: All heating, cooling and condensing water systems shall be adjusted to provide required quantity to or through each component.

C. Metering: Water quantities and pressures shall be measured with calibrated meters.

1. Venturi tubes, orifices, or other metering fittings and pressure gauges shall be used to measure water flow rates and balance systems. Systems shall be adjusted to provide the approved pressure drops through the heat transfer equipment (coils except room units, converters, etc.) prior to the capacity testing.
2. Where flow metering fittings are not installed, in air/water type heat transfer equipment, flow balance shall be determined by measuring the air side energy differential across the heat transfer equipment. Measurement of water temperature differential shall be performed with the air system, adjusted as described herein, in operation.

D. Automatic Controls: Automatic control valves shall be positioned for full flow through the heat transfer equipment of the system during tests.

E. Flow: Flow through bypass circuits at three-way valves shall be adjusted to equal that through the supply circuit, when the valve is in the bypass position.

F. Distribution: Adjustment of distribution shall be affected by means of balancing devices (cocks, valves, and fittings) and automatic flow control valves as provided. Manual service valves shall not be used for balancing.
1. Where automatic flow control valves are utilized in lieu of Venturi tubes, only pressure differential need be recorded, provided that the pressure is at least the minimum applicable to the tag rating.

G. Special Procedures: Where available pump capacity (as designed) is less than total flow requirements of individual heat transfer units of system served, full flow may be simulated by the temporary restriction of flow to portions of the system; specific procedures shall be delineated in the agenda.

H. Water System Test and Balance Procedure: Perform the following tests, and balance each system in accordance with the following requirements:
1. Set chilled, heating and condenser water pumps to proper gallons per minute delivery.
2. Adjust chilled water flow though chiller(s).
3. Adjust heating water flow through boiler(s).
4. Adjust condenser water flow through cooling tower(s).
5. Test and record entering and leaving water temperatures through chillers, boilers, heat exchangers and cooling towers/fluid coolers.
6. Test and record water temperatures at inlet and outlet side of each terminal unit. Note rise or drop of temperatures from source.
7. Proceed to balance each terminal unit.
8. Upon completion of flow readings and adjustments at coils, mark all settings and record data.
9. After adjustments to coils are made, recheck settings at the pumps, chiller, boilers, and cooling towers and readjust if required.
10. Record and check the following items at each coil.
    a. Inlet water temperatures.
    b. Leaving water temperatures.
    c. Water pressure drop of each coil.
11. Pump operating suction and discharge pressures and final total dynamic head.
12. List all mechanical specifications of pumps.
13. Rated and actual running amperage of pump motor.
14. Water metering device readings.

3.08 WATER SYSTEM DATA

A. Report: The certified report for reach water system shall include the data listed below.
1. Pumps:
    a. Installation data
        1) Manufacturer and model
        2) Size
        3) Type drive
        4) Motor hp, voltage, phase, and full load amps

b. Design data
   1) GPM
   2) Head
   3) RPM and amps
c. Recorded data
   1) Discharge pressures (full-flow and no-flow)
   2) Suction pressures (full-flow and no-flow) operating head
   3) Operating gpm (from pump curves if metering is not provided) no-load
   4) Amps
   5) Full-flow amps
   6) No-flow amps

2. Air Heating and Cooling Equipment:
   a. Design data
      1) Load in Btuh or MBh
      2) GPM
      3) Entering and leaving water temperature
      4) Entering and leaving air conditions (DB and WB)
      5) CFM
      6) Water pressure drop
      7) Entering steam pressure
   b. Recorded data
      1) Type of equipment and identification (location or number designation)
      2) Entering and leaving air conditions (DB and WB)
      3) Entering and leaving water temperatures
      4) GPM
      5) Temperature rise or drop
      6) Entering steam pressure
3. Boilers:
   a. Installation data
      1) Manufacturer and model
      2) Motor hp, voltage, cycles, phase, and full load amps
      3) Part load amperes
      4) GPM
      5) Water pressure drop
      6) Entering and leaving water temperature
   b. Recorded data
      1) GPM
      2) Water pressure drop
      3) Entering and leaving water temperature
      4) Amperes
4. Heat Exchangers:
   a. Installation Data
      1) Manufacturer, model, and type
      2) Flow rate
      3) Inlet (entering) and outlet (leaving) temperatures
      4) Inlet (entering) and outlet (leaving) pressures
   b. Recorded Data
      1) Flow rate
      2) Entering and leaving water temperatures
      3) Entering and leaving pressures

3.09 HEAT EXCHANGER CAPACITY VERIFICATION

A. Air coil capacities shall be verified from air side measurement data. Capacities of coils shall be the difference of the energy carried by the air between the upstream and downstream of the coils.

B. The measured air flow rate for the fan may be used for air coil capacity calculations providing no ducted bypassing of coil is occurring.

C. Water/water heat exchanger equipment capacity shall be verified by measuring the flow rate and temperature differential of the water.

D. Capacity verification shall be performed after air and water systems have been balanced.

E. False load shall be applied if the upstream air or water does not meet the specified conditions at the time of test.

3.10 SOUND TEST PROCEDURES

A. Scope: Tests of sound levels shall be made at each selection point as described in the following:
   1. Each normally occupied room or space, including, but not limited to, the following:
      a. Offices, open and enclosed.
      b. Conference rooms and breakout rooms.
      c. Lobbies and waiting rooms.
      d. Break rooms.
      e. Retail spaces.
      f. Dining area.
      g. Hospitality spaces, guest rooms and patient rooms.
      h. IT and data equipment rooms.
   2. Within five feet of each piece of noise generating equipment, such as chillers, cooling towers/fluid coolers, fans, compressors, pumps, and condensers. Or, within the documented sound measurement distance as listed in the equipment manufacturer literature.
   3. Within five feet of property lines where mechanical equipment is located outside the building.

B. Timing: Sound level measurements shall be taken at times when the building is unoccupied, or when activity in surrounding areas and background noise level in areas tested are at a minimum and relatively free from sudden changes in noise levels.
   1. Measurements shall be taken with all equipment turned off, except that being tested.
   2. The required sound levels shall be measured at any point within a room not less than 6 feet from any equipment or air terminal and not closer than 3 feet from any floor, wall, or ceiling surface.

C. Meters: Sound levels shall be measured with a sound meter complying with ANSI S1.4. The "A" scale shall be used to measure over all sound levels. To determine the specified octave band levels, the above sound level meter, set on "C" scale, shall be supplemented by an octave band analyzer complying with ANSI S1.11.

D. Equipment Components: The "Equipment Component" of room sound equals LPt-C. The "Equipment Component" of room sound (noise) levels shall be determined for each of eight octave bands as follows:
   1. Measure room sound pressure level "LPb" with equipment to be tested shut off.
   2. Measure room sound pressure level "LPt" with equipment to be tested turned on.
   3. Calculate LPt-LPb; if this value is less than 1, applicable test must be rerun with lower background level (LPb) unless LPt is within sound pressure level specified for equipment.
   4. Determine "c" from the table below.

LPt-LPb (db)	c (db)
1	7
2	4
3	3
4 to 4- ½	2
5 to 5- ½	1 – ½
6 to 7- ½	1
8 to 12	½
over 12	0

3.11 SOUND LEVEL DATA

A. Report: Certified report shall record data on sound levels, taken at each selected location, as follows:
   1. Source of sound and location.
   2. Diagram or description of relationship of sound source to measuring instrument.
   3. "A" scale readings equipment being tested turned off (ambient) equipment being tested turned on (operating conditions).
   4. Readings at each specified octave band frequency for equipment being tested turned off (ambient level) and equipment being tested turned on (operating conditions).
   5. "Equipment Components" of sound (noise) levels with applicable calculations per "Sound Test Procedures".
   6. Graph showing relationship between pressure levels specified and recorded readings

B. Retest: Subsequent to any correctional construction work, such as acoustic corrections, measurement shall be made to verify that associated air and water quantities, as previously measured, have not been disrupted.
   1. Certified report shall record all sound data, and their locations, after final adjustments of air and water systems involves

3.12 BALANCING MEASUREMENT TOLERANCES

A. Comply with codes and standards applicable for this project and local AHJ.

B. Comply with maximum tolerance air balance limitations listed in the ASHRAE Handbook – HVAC Applications (latest edition) and as listed in the following guidelines:
   1. Air terminal units: -2% to +10% of design air flows.
   2. Minimum Outside Air: -2% to +10% of design air flows.
   3. For negative pressure rooms: 0% to +10% or design exhaust air flows and balance supply air from -10% percent to 0% of design supply air flows.
   4. For positive pressure rooms: 0% to +10% of supply air flows and balance exhaust/return from -10% to 0% of design air flows.
   5. For rooms with less than 200 cfm, that are not indicated by plans or code to be positive or negative, balance the supply/return/exhaust from -5% to +5% of design air flows.
   6. Supply fans, return fans, exhaust fans and equipment with fans: 0% to +10% of design air flows.
   7. Air outlets and inlets: -/+ 5% of design air flows.
   8. Reheat heating water flow rate: -/+ 10% of design water flows.
   9. Preheat heating water flow rate: 0% to +10% of design water flows.
   10. Chilled water flow rate: 0% to +10% of design water flows.
   11. Condenser water flow rate: 0% to +10% of design water flows.

3.13 CERTIFIED REPORTS

A. Submittals: Six (6) copies of the reports described herein, covering air and water system performance, air motion (fpm), and sound pressure levels, shall be submitted prior to final tests and inspection.

B. Instrument Records: Types, serial numbers, and dates of calibration of all instruments shall be included.

C. Reports: Reports shall conspicuously identify items not conforming to contract requirements, or obvious malfunction and design deficiencies.

D. Certification: Certification shall include checking of adherence to agenda, of calculations, of procedures, and evaluation of final summaries.

3.14 FINAL COMMISSIONING TESTS, INSPECTIONS AND ACCEPTANCE

A. Scope: Test shall be made to demonstrate that capacities and performance of air and water systems comply with contract requirements.

1. At the time of final inspection, the Contractor shall recheck, random selection of data (water and air quantities, air motion, and sound levels) recorded in the certified report. In addition, all courtrooms, auditoriums, and conference rooms shall be rechecked.
2. Points and areas for recheck shall be selected by the commissioning team.
3. Measurement and test procedures shall be the same as approved for work forming basis of certified report.
4. Selections for recheck (specific plus random), in general, will not exceed 25 percent of the total number tabulated in the report, except that special air systems may require a complete recheck for safety reasons.

B. Retests: If random tests elicit a measured flow deviation of 10 percent or more from design, or a sound level greater than 2 db or more than recorded in the certified report listings, as 10 percent or more of the rechecked selections, the report shall be automatically rejected. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded, new certified reports submitted, and new inspection tests made, all at no additional cost. Retainage time shall be based on the date of the final acceptance of the certified report.

C. Marking of Settings: Following final acceptance of certified reports, the settings of all valves, splitters, dampers, and other adjustment devices shall be permanently marked by the Contractor so that adjustment can be restored if disturbed at any time. Devices shall not be marked until after final acceptance.

END OF SECTION

PART 1 GENERAL

1.01 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, and Section 230500 - Basic Materials and Methods, and other Sections in Division 23 specified herein.

1.02 SCOPE

A. All work to be furnished and installed under this Section shall include, but not necessarily be limited to, providing insulation for the following:
   1. HVAC Equipment Insulation section includes the following equipment that is not factory insulated
      a. Chilled-water pumps.
      b. Heating hot-water pumps.
      c. Heat-recovery pumps.
      d. Steam condensate pumps.
      e. Expansion/compression tanks.
      f. Air separators.
      g. Thermal storage tanks.
      h. Deaerators.
      i. Steam condensate tanks.
      j. Steam flash tanks, flash separators, moisture separators, and blow-off tanks.
      k. Piping system filtration unit housings.

B. Types of mechanical insulation specified in this Section include the following:
   1. Glass fiber and mineral wool.
   2. Closed cell phenolic.
   3. Polyisocyanurate.
   4. Calcium silicate.
   5. Cellular glass.
   6. Flexible elastomeric closed-cell foam.
   7. Aerocel.

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Division 22: Plumbing.

B. Section 230500: Basic HVAC Materials and Methods.

C. Section 232113: Hydronic Piping, Valves and Specialties.

1.04 DEFINITIONS

A. Ambient: The air temperature to be maintained in a conditioned room. Typically, between 70°F and 78°F.

B. Insert: Spacer placed between the pipe support system and the piping to allow for the space required for insulation.

C. Insulation Group (IG): Definition of Insulation Materials and Operating Temperatures.

D. Insulation Shield: Buffer material placed between the pipe support system and the insulation to prevent the insulation material from crushing.

E. Jacket: Protective covering over the pipe insulation; may be factory applied such as “all service jacket” or field applied to provide additional protection; of such materials as canvas, PVC, aluminum or stainless steel.

F. Piping Insulation: Thermal insulation applied to prevent heat transmission to or from a piping system.

G. Vapor Barrier Jacket: Insulation jacket material that impedes the transmission of water vapor.

H. Freezing Climate: Where outdoor design temperature is less than 33º F, as stated in ASHRAE fundamentals under 99% column for winter design conditions.

I. Unconditioned Space: any space not directly conditioned by mechanical equipment or maintained to temperature by mechanical equipment.

1.05 INSULATION INDUSTRY DEFINITIONS

A. UL GREENGUARD: Provides independent third-party, Indoor Air Quality (IAQ) certification of products for emissions of respirable particles and Volatile Organic Compounds (VOC's), including formaldehyde and other specific product-related pollutants. Certification is based upon criteria used by EPA, OSHA, and WHO.

B. EPA: Environmental Protection Agency.

C. WHO: World Health Organization.

D. ASJ+: All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film layer leaving no paper exposed.

E. ASJ: All Service Jacket (no outer film).

F. SSL+: Self-Sealing Lap with Advanced Closure System.

G. SSL: Self-Sealing Lap.

H. FSK: Foil Scrim Kraft; jacketing.

I. FSP: Foil Scrim Polyethylene jacketing

J. PSK: Poly Scrim Kraft; jacketing.

K. PVC: Polyvinyl Chloride.

L. FHC: Fire Hazard Classification

M. Glass Mineral Wool: Interchangeable with fiber glass, but replacing the term in the attempt to disassociate and differentiate Glass Mineral Wool from the potential health and safety risk of special purpose or reinforcement products that do not meet the bio solubility criteria of insulation made from glass. Rock Mineral Wool will replace the traditional Mineral Wool label. Both are used in lieu of the Mineral Fiber label.

N. ECOSE Technology: a proprietary binder system based on rapidly renewable bio-based materials; rather than petroleum-based chemicals commonly used in other glass mineral wool insulation materials. ECOSE Technology reduces the binder embodied energy by up to 70 percent and does not contain phenol, formaldehyde, acrylics or artificial colors.

O. UL GREENGUARD Gold Certification: (formerly known as GREENGUARD Children & Schools Certification) offers stricter certification criteria, considers safety factors to account for sensitive individuals (such as children and the elderly), and ensures that a product is acceptable for use in environments such as schools and healthcare facilities. It is referenced by both The Collaborative for High Performance Schools (CHPS) and the Leadership in Energy Environmental Design (LEED) Building Rating Systems.

P. Recycled Content – Post-Consumer: materials such as bottled glass collected at curbside or other collection sites after consumer use and used in the manufacturing process to create a new product rather than being placed in a landfill or incinerated.

Q. Recycled Content – Pre-Consumer (aka Post-Industrial): materials used or created from one manufacturing process which are collected as scrap and placed back into another manufacturing process rather than being placed in a landfill or incinerated.

R. Polybrominated diphenyl ethers (PBDE) such as Penta-BDE, Octa-BDE and Deca-BDE fire retardants: have been linked to adverse health effects after exposure in low concentrations.

S. UL Classified: UL has tested and evaluated samples of the product with respect to certain properties of the product. UL classifies products to applicable UL requirements standards for safety and standards of other National and International organizations

T. Imperative 11, Red List – requires that manufacturers disclose the ingredients in their products to confirm they are free of Red List chemicals and materials. The Red List represents the “worst in class” materials, chemicals and elements known to pose serious risks to human health and the greater ecosystem.

U. Underwriter's Laboratories Environment (UL Environment): offers independent green claims validation, product assessment and certification.

V. UL Environment Claims Validation (ECV): service and label tests a manufacturer's product and validates that the environmental claims they make in their marketing and packaging materials are factual. This ECV service enables products to qualify for LEED® MR Credit 4 Recycled Content LEED-NC 2009 or New LEED V-4 Building product disclosure and optimization – sourcing of raw materials.

1.06 QUALITY ASSURANCE

A. Codes and Standards: Provide products conforming to the requirements of the following:
   1. American Society for Testing and Materials (ASTM): Manufacture and test insulation in accordance with the ASTM Standards, including:
      a. B209 - Specification for Aluminum and Aluminum-Alloy Sheet and Plat.
      b. C165 - Recommended Practice for Measuring Compressive Properties of Thermal Insulation.
      c. C168 – Terminology for Thermal Insulation
      d. C177 - Test Method for Steady-State Heat Flux Measurements and Thermal Transmission.
      e. Properties by Means of the Guarded-Hot-Plate Apparatus.
      f. C195 - Specification for Mineral Fiber Thermal Insulating Cement.
      g. C196 - Specification for Expanded or Exfoliated Vermiculite Thermal Insulating Cement.
      h. C302 - Test Method for Density of Preformed Pipe-Covering-Type Thermal Insulation.
      i. C303 - Test Method for Density of Preformed Block-Type Thermal Insulation.
      j. C305 - Test for Thermal Conductivity of Pipe Insulation.
      k. C356 - Test for Linear Shrinkage of Preformed High-Temperature Thermal Insulation.
      l. C411 - Test for Hot-Surface Performance of High Temperature Thermal Insulation.
      m. C423 – Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
      n. C449 - Specification of Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
      o. C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
      p. C533 - Specification for Calcium Silicate Block and Pipe Thermal Insulation.
      q. C534 - Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
      r. C547 - Specification for Mineral Fiber Preformed Pipe Insulation.
      s. C552 - Specification for Cellular Glass Block and Pipe Thermal Insulation.
      t. C553 - Specification for Mineral Fiber Blanket-Type Pipe Insulation (Industrial Type).
      u. C592 - Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered).
      v. C612 - Specification for Mineral Fiber Block and Board Thermal Insulation.
      w. C795 – Standard Practice for Quantitative Accelerated Laboratory Evaluation of Extraction Solutions Containing Ions Leached from Thermal Insulation on Aqueous Corrosion of Metals.
      x. C921 - Practice for Determining Properties of Jacketing Materials for Thermal Insulation.
      y. C1104 - Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation.
      z. C1071 - Standard Specification for Thermal and Acoustical Insulation.
      aa. C1338 - Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
      bb. C1617 Standard Specification for Thermal Insulation for use in Contact with Austenitic Stainless Steel.
      cc. D1667 – Standard Specification for Flexible Cellular Material-Vinyl Chloride Polymers and Copolymers (Closed-Cell Foam).
      dd. E84 - Test Method for Surface Burning Characteristics of Building Materials.
      ee. E119 - Test for Fire Resistance.
      ff. G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
      gg. G22 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Bacteria.

2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): Provide and install pipe and duct insulation in accordance with the following ASHRAE Standard:
   a. 90 - Energy Conservation in New Building Design.
3. National Fire Protection Association (NFPA): Manufacture insulation in accordance with the following NFPA standards:
   a. 255 - Test Methods, Surface Burning Characteristics of Building Materials.

B. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

C. Do not provide materials with flame proofing treatments subject to deterioration due to the effects of moisture or high humidity.

D. Flame/Smoke Rating: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing; or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified.

E. Corrosiveness: Provide insulation such that when tested in accordance with the following test, the steel plate in contact with the insulation shows no greater corrosion than sterile cotton in contact with a steel plate for comparison.
   1. Test Specimen: Two specimens shall be used, each measuring 1” by 4” by approximately 1/2” thick.
   2. Apparatus: Provide a humidity test chamber in which two polished-steel test plates, 1” wide, 4” long and 0.020” thick, shall be placed. Plates shall be clear finish, cold-rolled strip steel, American quality, quarter hard, temper No. 3, weighing 0.85 lbs./sq. ft.
   3. Procedure: The steel test plates shall be rinsed with cp benzol until their surfaces are free from oil and grease and allowed to dry. One piece of cold-rolled steel shall be placed between the two insulation specimens and secured with tape or twine. The test specimen and uncovered plate shall be suspended vertically in an atmosphere having a relative humidity of 95% (plus or minus 3%), and a temperature of 120°F (plus or minus 3°F), for 96 hours, and then be examined for corrosion.

F. Insulation thickness shall be the greater standard of that specified here or the State energy conservation requirements.

G. Sustainable Project Requirements:
   1. Formaldehyde Free: Third party certified with UL Environment Validation or Scientific Certification Systems (SCS).
   2. Biosoluble: As determined by research conducted by the International Agency for Research on Cancer (IARC) and supported by revised reports from the National Toxicology Program (NTP) and the California Office of Environmental Health Hazard Assessment. Certified by European Certification Board for Mineral Wool Products (EUCEB).
   3. Low Emitting Materials: For all thermal and acoustical applications of Glass Mineral Wool Insulation Products, provide materials complying with the testing and products requirements of UL GREENGUARD standards for Low-Emitting Products.
   4. Living Building Challenge-Declare Red List Free.

1.07 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, K-value, thickness, and furnished accessories for each mechanical system requiring insulation.

B. Products containing the following prohibited chemicals for use as flame retardants or for other purposes will not be acceptable when present in quantities greater than 0.1% by mass. Provide a statement with the submittal indicating that no product submitted contains an amount equal to or greater than 0.10% by mass of the following chemicals:
   1. Pentabrominated diphenyl ether (CAS#32534-81-9)

2. Octabrominated diphenyl ether (CAS#32536-52-0)
3. Decabrominated diphenyl ether (CAS#1163-19-50

C. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product in maintenance manual.

1.08 LEED ACTION SUBMITTALS:

A. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

B. Product Data for Credit MR 5 Regional Materials: For products and materials to comply with requirements for regional materials, provide documentation indicating location of product or material, manufacturing location and the point of extraction, harvest or recovery for each raw material. Include distance to Project, contractor cost for each regional material, and percent by weight that is considered regional.

C. LEED v 4, Product Data for Credit EA 2: For products and materials significant to the energy performance of a structure, provide documentation that indicates that insulation levels are significant to increasing the level of energy performance beyond the prerequisite standard.

D. LEED v 4, Product Data for Credit MR 2: For products and materials to comply with Building Product Disclosure & Optimization, provide data/evidence that substantiates Environmental Product Declaration and Multi Attribute Optimization requirements.

E. LEED v 4: Product Data for Credit MR 3: For products and materials to comply with requirements for regional materials, provide documentation indicating location of product or material, manufacturing location and the point of extraction, harvest or recovery for each raw material. Include distance to Project, contractor cost for each regional material, and percent by weight that is considered regional.

F. LEED v 4, Product Data for Credit MR 4: For products having recycled content documentation; indicating percentages by weight of post-consumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.

G. LEED v 4, Product Data for Credit EQ 2: For products and materials to comply with low emittance standards, provide documentation substantiating that insulation products comply with requisite low emittance standards.

H. LEED v 4, Product Data for Credit EQ 5: For products and materials to meet the standard for both thermal comfort design and thermal comfort control, provide data to support that insulation products are significant to thermal comfort design and thermal comfort control.

I. LEED v 4, Product Data for Credit EQ 9: For products and materials that contribute to the design and performance of workspaces that promote occupants well-being, productivity, and communication, provide data/documentation supporting acoustical benefits of Glass Mineral Wool insulation products.

J. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

1.09 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coating to the site in containers with manufacturer's stamp or label affixed showing fire hazard indexes of products.

B. Store and protect insulation against dirt, water, chemical, and mechanical damage. Do not install damaged or wet insulation; remove from project site.

1.10 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Comply with requirements in "PART 3-EXECUTION, Table 1: Equipment Insulation Type Required" for application of insulating materials.

B. Products shall not contain asbestos, lead, mercury or mercury compounds if possible. Products shall be certified UL GREENGUARD Gold or Indoor Advantage Gold if possible.

C. Products that contact stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Each insulation material has been provided a descriptive key code, such as EI-A, to simplify the organization and application of materials in following sub-sections.

G. Acceptable manufacturers include Knauf, Johns Manville, Owens-Corning, Armstrong, Pittsburgh-Corning, Trymer, IIG, Certainteed, Halstead, Rubatex, 3M FireMaster, Pabco, Reflectix, Aeroflex, Armacell, Pacor or equal. Manufacturer and insulation types listed below indicate a minimum acceptable level of quality required for each classification.

2.02 EQUIPMENT INSULATION (IDENTIFIED BY KEY CODE EI AND IN TABLE 1)

A. **EI-A**, Rigid Hydrous Calcium Silicate:
1. Applications: High temperature insulation for piping and equipment and for placement at piping hangers and supports.
2. Compliant with ASTM C165, C302, C356, C447, C533, C665, C1338 and E84.
3. Maximum Service Temperature: 1200°F (650°C).
4. Thermal conductivity (K-value): 0.389 Btu•in./(hr•ft²•ºF), or less, at 200°F (93°C). Thickness as required to meet energy code requirements.
5. Nominal density is 14 lbs./cu. ft. or greater.
6. Compressive Strength (block): Minimum of 100 psi to produce 5% compression as tested per ASTM C165.
7. Surface Burning Characteristics: Flame Spread Index =0 and Smoke Developed Index =0 ratings as tested per ASTM E84.
8. Tie Wire: 16-gauge stainless steel with twisted ends on maximum 12” centers.
9. Product must contain corrosion inhibiting chemistry.
10. Manufacturers: Johns Manville Industrial Insulation Group #Thermo-12 Gold or equal.

B. **EI-B,** Rigid Closed-Cell Cellular Glass:
1. Applications: Rigid closed cell glass impermeable to water and water vapor for insulating buried piping and equipment, as well as traditional application on other piping and equipment.
2. Compliant with ASTM C165, C240, C303, C450, C552, C585, E136, E1461, and E84.
3. Service Temperature Range: -450°F to 900°F (-268°C to 482°C).
4. Thermal conductivity (K-value): 0.29 Btu•in./(hr•ft²•ºF), or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
5. Water Vapor Absorption, % of volume: <0.2% (maximum) compliant with ASTM C240.
6. Nominal density is 8 lbs./cu. ft. or greater.
7. Compressive Strength (block): Minimum of 90 psi to produce 5% compression as tested per ASTM C165.
8. Surface Burning Characteristics: Flame Spread Index =0 and Smoke Developed Index =0 ratings as tested per ASTM E84.
9. Manufacturers: Pittsburgh-Corning #Foamglas One or equal

C. **EI-C,** Flexible Closed-Cell Elastomeric, Neoprene or Polyethylene:

1. Applications: Insulation of piping, fittings and equipment with thickness as required by local energy code.
2. Compliant with UL 181, ASTM C411, C518, C534, G21/C1338, G22, D1056 and E84. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
3. Service Temperature Range: -297°F to 220°F (-183°C to 105°C).
4. Thermal conductivity (K-value): 0.28 Btu•in./(hr•ft²•ºF), or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
5. Water Vapor Absorption, % of volume: <0.2% (maximum) compliant with ASTM C209.
6. Nominal density is 2.5 lbs./cu. ft. or greater.
7. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
8. Seal all seams and joints with contact adhesive or factory self-seal system with lap seal tape.
9. Manufacturers: Armacel #AP Armaflex, Rubatex #K-Flex ECO, Aeroflex #Aerocel or equal.

D. **EI-D**, Rigid Fiberglass Board:
1. Applications: Rigid fiberglass insulation board for insulation of ducts and plenums, tanks, and walls with integral vapor barrier. Thickness as required by local energy code. Insulation shall be provided with a jacket coordinated with the temperature service of the insulation. Glass fibers bonded with a thermosetting resin.
2. Compliant with ASTM C423, C553, C612, C665, C1101, C1136, C1338, E795 and E84.
3. Thermal conductivity (K-value): 0.25 Btu•in./(hr•ft²•ºF), or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
4. Service Temperature Range: 0°F to 250°F (-18°C to 121°C) for faced board.
5. Water Vapor Absorption, % of volume: <5% (maximum) as tested per ASTM C1104.
6. Vapor Retarder Jacket: Factory applied ASJ or FSK interleaving reinforced with glass fiber scrim yarn and bonded to aluminum foil.
7. Nominal density is 2.0 lbs./cu. ft. or greater.
8. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
9. Manufacturers: CertainTeed #CertaPro Commercial Board, Johns Manville #800 Series Spin-Glas, Knauf, Manson, Owens Corning or equal.

E. **EI-E**, Flexible Fiberglass Blanket:
1. Applications: Flexible insulation blanket for wrapping large pipes, tanks and equipment. Thickness as required by local energy code. Insulation shall be provided with a jacket coordinated with the temperature service of the insulation. Glass or mineral fibers bonded with a thermosetting resin.
2. Compliant with ASTM C167, C177, C411, C518, C612, C665, C1136, C1338, C1393, E96 and E84.
3. Thermal conductivity (K-value): 0.24 Btu•in./(hr•ft²•ºF), or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
4. Service Temperature Range: 35°F to 850°F (2°C to 454°C).
5. Water Vapor Absorption, % of volume: <5% (maximum) as tested per ASTM C1104.
6. Vapor Retarder Jacket: Factory applied ASJ or FSK interleaving reinforced with glass fiber scrim yarn and bonded to aluminum foil.
7. Nominal density is 2.5 lbs./cu. ft. or greater.
8. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
9. Manufacturers: CertainTeed #CrimpWrap, Johns Manville #Micro-Flex, Knauf, Manson, Owens Corning or equal.

F. **EI-F**, Rigid High Temperature Mineral Fiber Board:
1. Applications: Rigid high temperature insulation board for insulation of equipment and tanks with thickness as required by local energy code. Insulation shall be provided with a jacket coordinated with the temperature service of the insulation. Inorganic mineral fibers bonded with a thermosetting resin.
2. Compliant with ASTM C356, C447, C612, C665, C692, C795, C871, C1104 and E84.

3. Thermal conductivity (K-value): 0.25 Btu•in./(hr•ft²•ºF), or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
4. Service Temperature Range: 0°F to 1200°F (-18°C to 650°C).
5. Water Vapor Absorption, % of volume: <1% (maximum) as tested per ASTM C1104.
6. Nominal density is 6 lbs./cu. ft. or greater.
7. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
8. Manufacturers: Johns Manville #MinWool-1260, Owens Corning Thermafiber #Industrial Board, Johns Manville, Knauf, Manson, Rockwool, CertainTeed or equal.

G. **EI-G**, Flexible High Temperature Mineral Fiber Blanket:
1. Applications: Flexible high temperature insulation blanket for tanks and equipment with thickness as required by local energy code. Insulation shall be provided with a jacket coordinated with the temperature service of the insulation. Inorganic mineral fibers bonded with a thermosetting resin.
2. Compliant with ASTM C356, C447, C612, C665, C692, C795, C871, C1104 and E84.
3. Thermal conductivity (K-value): 0.25 Btu•in./(hr•ft²•ºF), or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
4. Service Temperature Range: 0°F to 1200°F (-18°C to 650°C).
5. Water Vapor Absorption, % of volume: <1% (maximum) as tested per ASTM C1104.
6. Nominal density is 6 lbs./cu. ft. or greater.
7. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
8. Manufacturers: Owens Corning Thermafiber #Industrial Blanket, Johns Manville, Knauf, Manson, Rockwool, CertainTeed or equal.

H. **EI-H**, Rigid Closed-Cell Phenolic Foam:
1. Applications: Insulation of piping, tanks, and equipment with thickness as required by local energy code.
2. Compliant with ASTM C209, C518, C795, C1126, D1621, D1622, D2856, D6226 and E84.
3. Service Temperature Range: -290°F to 250°F (-178°C to 121°C).
4. Thermal conductivity (K-value): 0.18 Btu•in./(hr•ft²•ºF) or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
5. Vapor Retarder Jacket – straight sections: Factory applied ASJ with SSL.
6. Water Vapor Absorption, % of volume: <0.87% (maximum) as tested per ASTM C209.
7. Nominal density is 2.5 lbs./cu. ft. or greater.
8. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
9. Manufacturers: ITW Trymer #Supercel, Kingspan #Koolphen K, Resolco #Insul-phen or equal.

I. **EI-I**, Rigid Closed-Cell Polyisocyanurate Foam:
1. Applications: Rigid preformed insulation of piping, fittings, vessels, and equipment with thickness as required by local energy code. Not for use in return air plenums or ventilation ductworks.
2. Compliant with ASTM C272, C591, C755, C1136, C920, D6226, E96, and E84.
3. Service Temperature Range: -297°F to 300°F (-183°C to 149°C).
4. Thermal conductivity (K-value): 0.19 Btu•in./(hr•ft²•ºF) or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
5. Water Absorption, % of volume: 0.7 (maximum) as tested per ASTM C272.
6. Vapor Retarder Jacket: Saran 540/SSL or Mylar laminate.
7. Nominal density is 2 lbs./cu. ft. or greater.
8. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤450 ratings as tested per ASTM E84. Not compliant for use in return air plenums.
9. Manufacturers: Trymer #2000 XP, Dyplast #ISO, HiTherm or equal.

J. **EI-J**, Rigid Extruded Polystyrene Foam Board:
1. Applications: Rigid board insulation for large outdoor tanks and vessels with thickness as required by local energy code. Not for use indoors.

2. Compliant with ASTM C203, C272, C518, C578, D121, D696, D1621, D2126, D2842 and E96.
3. Maximum Service Temperature: 165°F (75°C).
4. Thermal conductivity (K-value): 0.18 Btu•in./(hr•ft²•ºF), or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
5. Water Vapor Absorption, % of volume: <0.2% (maximum) compliant with ASTM C209.
6. Nominal density is 2.5 lbs./cu. ft. or greater.
7. Surface Burning Characteristics: Flame Spread Index =0 and Smoke Developed Index =155 ratings as tested per ASTM E84.
8. Seal all seams and joints with contact adhesive and provide field applied jacket system.
9. Manufacturers: Dow #Styrofoam or equal.

K. **EI-K**, Flexible Low Temperature Aerogel (Cold Fluid Piping and Equipment):
1. Applications: High performance flexible insulation for specialty insulation of low temperature piping and equipment with reduced available space or where higher thermal performance is required.
2. Compliant with ASTM C1728, C165, C1101/1101M, C1104/1104M, C1336, C1617, C1763 and E84.
3. Service Temperature Range: -200°F to 200°F (-129°C to 93°C).
4. Thermal conductivity (K-value): 0.12 Btu•in./(hr•ft²•ºF), or less, at 75°F (24°C). Thickness as required to meet energy code requirements.
5. Water Vapor Absorption, % of volume: ≤5% (maximum) as tested per ASTM C1104compliant with ASTM C240.
6. Nominal density is 10 lbs./cu. ft. or greater.
7. Compressive Strength: ≥ 5 psi to produce 10% compression as tested per ASTM C165.
8. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
9. Manufacturers: Pacor #Cryogel X201 or equal.

L. **EI-L**, Flexible High Temperature Aerogel (Hot Fluid Piping and Equipment):
1. Applications: High performance flexible insulation for specialty insulation of high temperature piping and equipment with reduced available space or where higher thermal performance is required.
2. Compliant with ASTM C177, C1728, C165, C1101/1101M, C1104/1104M, C1336, C1617, C1763, and E84.
3. Service Temperature Range: 32°F to 482°F (0°C to 250°C).
4. Thermal conductivity (K-value): 0.12 Btu•in./(hr•ft²•ºF), or less, at 212°F (100°C). Thickness as required to meet energy code requirements.
5. Water Vapor Absorption, % of volume: ≤5% (maximum) as tested per ASTM C1104compliant with ASTM C240.
6. Nominal density is 10 lbs./cu. ft. or greater.
7. Compressive Strength: ≥ 5 psi to produce 10% compression as tested per ASTM C165.
8. Surface Burning Characteristics: Flame Spread Index ≤5 and Smoke Developed Index ≤10 ratings as tested per ASTM E84.
9. Manufacturers: Pacor #Pryogel 2250.

M. **EI-M**, Flexible Extreme High Temperature Aerogel (High Temperature Exhaust Piping and Equipment):
1. Applications: High performance flexible insulation for specialty insulation of extreme high temperature piping and equipment with reduced available space or where higher thermal performance is required.
2. Compliant with ASTM C177, C1728, C165, C1101/1101M, C1104/1104M, C1336, C1617, C1763, and E84.
3. Service Temperature Range: 32°F to 1200°F (0°C to 650°C).
4. Thermal conductivity (K-value): 0.16 Btu•in./(hr•ft²•ºF), or less, at 212°F (100°C). Thickness as required to meet energy code requirements.
5. Water Vapor Absorption, % of volume: ≤5% (maximum) as tested per ASTM C1104compliant with ASTM C240.
6. Nominal density is 12.5 lbs./cu. ft. or greater.
7. Compressive Strength: ≥ 5 psi to produce 10% compression as tested per ASTM C165.

8. Surface Burning Characteristics: Flame Spread Index ≤5 and Smoke Developed Index ≤10 ratings as tested per ASTM E84.
9. Manufacturers: Pacor #Pryogel XTE.

2.03 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ+: White, polypropylene-coated, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
3. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
4. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
5. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
6. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.04 JACKETING MATERIALS

A. Field Applied Jackets (For Indoor Applications):
1. All longitudinal seams shall be located on bottom of pipes.
2. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
3. PVC Plastic:
   a. High-impact-resistant, UV-resistant PVC as tested per ASTM C553, C547, C665, C795, C1338, D1784, E96, C1136 and D3679.
   b. One piece molded type fitting covers and jacketing material.
   c. Adhesive: As recommended by jacket material manufacturer.
   d. Color: White.
   e. Thickness: 20 mil (0.5 mm), minimum.
   f. Service Temperature Range: 0°F to 150°F (-18°C to 66°C).
   g. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
   h. Manufacturers: Johns Manville #Zeston 2000, Proto #LoSmoke, PIC Plastics, Proto Corporation, Speedline Corporation or equal.
4. Aluminum Jacket:
   a. Comply with ASTM B209/B209M.
   b. Aluminum alloy 3003, 3005, 3105 or 5005 with an H-14 temper.
   c. Thickness: 0.016” thick sheet (minimum).
   d. Finish: Smooth or stucco embossed
   e. Moisture Barrier: 3 mil thick polysurlyn or 3 mil thick polyethylene.
   f. Longitudinal slip joints and 2” laps, die shaped fitting covers with factory attached protective liner. Secure with 3/8” or 1/2” stainless steel bands on 12” centers.
   g. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
   h. Manufacturers: Pabco, Childers, RPR, ITW or equal.
5. Canvas Jacket:
   a. Cotton or fiberglass cloth.
   b. UL listed fabric treated with dilute fire retardant.
   c. Lagging adhesive per manufacturer.
   d. Manufacturers: GJC General, GLT Products, Foster #Mast-A-Fab, Childers #Chil-Glas No. 5 or equal.

B. Field Applied Jackets (For Outdoor Applications):
   1. All longitudinal seams, on horizontal pipe runs, shall be installed on the bottom of pipes.
   2. Secure stainless steel or aluminum jackets with 3/8” or 1/2” stainless steel bands on 12” centers and at each joint.
   3. PVC Jacket: Not allowed for outdoor applications.
   4. Canvas Jacket: Not allowed for outdoor applications.
   5. Aluminum Jacket:
      a. Comply with ASTM B209/B209M.
      b. Aluminum alloy 3003, 3005, 3105 or 5005 with an H-14 temper.
      c. Thickness: 0.016” thick sheet (minimum).
      d. Finish: Smooth, stucco embossed or corrugated surface.
      e. Moisture Barrier: 3 mil thick polysurlyn or 3 mil thick polyethylene.
      f. Longitudinal slip joints and 2” laps, die shaped fitting covers with factory attached protective liner. Secure with 3/8” or 1/2” stainless steel bands on 12” centers.
      g. Manufacturers: Pabco, Childers, RPR, ITW or equal.
   6. Self-Adhesive Aluminum Jacket:
      a. Comply with ASTM D774, C1338, C1371, E96, and D882.
      b. Thickness: 56 mils (minimum).
      c. Multi-ply UV-resistant aluminum foil/polymer laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with stucco-embossed aluminum-foil facing.
      d. Weight: 0.3 lbs./sf, minimum.
      e. Service Temperature Range: -15°F to 160°F (-26°C to 71°C).
      f. Manufacturers: Polyguard Products #Alumaguard or equal.
   7. Stainless Steel Jacket:
      a. Comply with ASTM A240 and A666.
      b. Stainless steel alloy T-304 or T-316. T-316 shall be used in corrosive environments including close proximity to coast.
      c. Thickness: 0.016” thick sheet (minimum).
      d. Dull Finish: Smooth, stucco embossed or corrugated surface.
      e. Moisture Barrier: 3 mil thick polysurlyn or 3 mil thick polyethylene.
      f. Longitudinal slip joints and 2” laps, die shaped fitting covers with factory attached protective liner. Secure with 3/8” or 1/2” stainless steel bands on 12” centers.
      g. Manufacturers: Pabco, Childers, RPR, ITW or equal.

C. Removable Covers:
   1. Provide removable covers on indoor pumps, valves, air separators, air vent fittings, flanges, strainers, traps, etc., where periodic maintenance or removal of insulation is required.
      a. Pre-molded insulation covers:
         1) Cold Systems: Provide PVC covers over insulated elbows, fittings and flanges.
         2) Cold Systems: Provide flexible closed cell foam or removable cloth insulating blankets for valves, pumps and strainers.
         3) Hot Systems: Provide PVC covers over insulated elbows, fittings and flanges.
         4) Hot Systems: Provide removable cloth insulating blankets on valves, pumps, and strainers.
      b. Removable cloth insulating blankets:
         1) Service Operating Temperature: 0-350°F.
         2) Jacket and Liner: silicon or teflon impregnated mineral wool cloth.
         3) Liner Reinforcement: stainless steel mesh cloth.
         4) Insulation: Fiberglass matt or Pacor #Aerogel, 2” thick (minimum) or R-8 equivalent (minimum), and thicker as required by local energy code.
         5) Fastening: 2” Nomex Velcro or 1” straps and stainless steel D-rings or 12-gage stainless steel hooks and stainless steel wire.
         6) Thread: Kevlar/stainless steel thread.

7) Outdoor Applications: Jacket shall be UV and ozone resistant with Velcro attachment.
8) Manufacturers: Thermal Energy Products, Coverflex, Thermaxx, Pacor, Unitherm, Advance Thermal, Fit Tight Covers, Alpha or equal.

2.05 CORNER ANGLES

A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch (1.0 mm thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: 0.024 inch (0.61 mm thick, minimum 1 by 1 inch (25 by 25 mm), stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304

2.06 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Calcium Silicate Adhesive:
1. Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 1200°F (10 to 649°C).
2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Manufacturers: Childers Brand #CP-97, Johns Manville #CalBond Gold, Marathon Industries #290, Foster Brand #81-27, Mon-Eco Industries #22-30, Vimasco Corporation #760 or equal.

C. Cellular-Glass Adhesive:
1. Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200°F (minus 73 to plus 93°C).
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Manufacturers: Foster Brand #81-84 or equal.

D. Phenolic and Polyisocyanurate Adhesive:
1. Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300°F (minus 59 to plus 149°C).
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Manufacturers: Childers Brand #CP-96, Foster Brand #81-33 or equal.

E. Flexible Elastomeric and Polyolefin Adhesive:
1. Comply with MIL-A-24179A, Type II, Class I.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Manufacturers: Aeroflex USA, Inc.; Aeroseal, Armacell LLC; Armaflex #520 Adhesive, Foster Brand #85-75, K-Flex USA #R-373 Contact Adhesive or equal.

F. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Manufacturers: Childers Brand #CP-127, Eagle Bridges - Marathon Industries #225, Foster Brand #85-60/85-70, Mon-Eco Industries, Inc.#22-25 or equal.

G. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Manufacturers: Childers Brand #CP-82, Eagle Bridges - Marathon Industries #225, Foster Brand #85-50, Mon-Eco Industries, Inc.#22-25 or equal.

H. PVC Jacket Adhesive: Compatible with PVC jacket.
1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Manufacturers: Dow Corning Corporation #739, Dow Silicone, Johns Manville #Zeston Perma-Weld, CEEL-TITE #Solvent Welding Adhesive, P.I.C. Plastics, Inc. #Welding Adhesive, Speedline Corporation #Polyco VP Adhesive or equal.

2.07 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based for indoor use.
1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43 mil (1.09 mm) dry film thickness.
2. Service Temperature Range: -20°F to 180°F (-29 to 82°C).
3. Vapor Safe Coating: Shall meet requirements of LEED IEQ Low-Emitting Materials. VOC 33 g/l, less water and exempt solvents.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.
6. Manufacturers: Foster Brand #30-80/30-90, Vimasco Corporation #749 or equal.

C. Vapor-Barrier Mastic: Solvent based for outdoor use.
1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30 mil (0.8 mm) dry film thickness.
2. Service Temperature Range: -50°F to 220°F (-46 to 104°C).
3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
4. Color: White.
5. Manufacturers: Childers Brand #Encacel X CP-40, Eagle Bridges - Marathon Industries #570, Foster Brand #60-95/60-96 or equal.

D. Breather Mastic: Water based for indoor and outdoor use.
1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625 inch (1.6 mm) dry film thickness.
2. Service Temperature Range: -20°F to 180°F (-29 to 82°C).
3. Solids Content: 60 percent by volume and 66 percent by weight.
4. Color: White.
5. Manufacturers: Childers Brand #CP-10/CP-11, Eagle Bridges - Marathon Industries #550, Foster Brand #46-50, Mon-Eco Industries, Inc. #55-50, Vimasco Corporation #WC-1/WC-5 or equal.

2.08 LAGGING ADHESIVES

A. Adhesives shall be compatible with insulation materials, jackets, and substrates.
1. Comply with MIL-A-3316C, Class I, Grade.
2. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
4. Service Temperature Range: 0 to 180°F (-18 to 82°C).
5. Color: White.
6. Manufacturers: Childers Brand #CP-50 AHV2, Foster Brand #30-36, Vimasco Corporation #713/714 or equal.

2.09 SEALANTS

A. Joint Sealants:
1. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate.
   a. Manufacturers: Childers Brand #CP-76, Marathon Industries#405, Foster Brand #30-45, Mon-Eco Industries, Inc.#44-05, Pittsburgh Corning Corporation #Pittseal 444 or equal.
2. Joint Sealants for Polystyrene.
   a. Manufacturers: Childers Brand #CP-70, Marathon Industries #405, Foster Brand #30-45, Mon-Eco Industries, Inc.#44-05 or equal.
3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: -100 to 300°F (-73 to 149°C).
6. Color: White or gray.
7. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24). Shall be compliant with requirements of LEED IEQ Low-Emitting Materials.

B. FSK and Metal Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250°F (Minus 40 to plus 121°C).
4. Color: Aluminum.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Manufacturers: Childers Brand #CP-76, Eagle Bridges - Marathon Industries #405, Foster Brand #95-44, Mon-Eco Industries, Inc. #44-05 or equal.

C. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250°F (Minus 40 to plus 121°C).
4. Color: White.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Manufacturers: Childers Brand #CP-76 or equal.

2.10 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Width: 3 inches (75 mm).
2. Thickness: 11.5 mils (0.29 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
7. Manufacturers: ABI, Ideal Tape Division #428 AWF ASJ, Avery Dennison Corporation #Fasson 0836, Compac Corporation #105, 3M Venture Tape #1540 CW Plus/1542 CW Plus/1542 CW Plus/SQ or equal.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Width: 3 inches (75 mm).
2. Thickness: 6.5 mils (0.16 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.

6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
7. Manufacturers: ABI Tape #491 AWF FSK, Avery Dennison Corporation #Fasson 0827, Compac Corporation #110 and 111, 3M Venture Tape #1525 CW NT/1528 CW/1528 CW/SQ or equal.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Width: 2 inches (50 mm).
2. Thickness: 6 mils (0.15 mm).
3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
6. Manufacturers: ABI Tape #370 White PVC tape, Compac Corporation #130, Venture Tape #1506 CW NS or equal.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Width: 2 inches (50 mm).
2. Thickness: 3.7 mils (0.093 mm).
3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.
6. Manufacturers: ABI Tape #488 AWF, Avery Dennison Corporation #Fasson 0800, Compac Corporation #120, 3M Venture Tape #3520 CW or equal.

2.11 SECUREMENTS

A. Bands:
1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304, 0.020 inch (0.50 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal.
2. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
3. Manufacturers: ITW Insulation Systems, Gerrard, RPR or equal.

B. Insulation Pins and Hangers:
1. Capacitor-Discharge-Weld Pins:
   a. Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106 inch (2.6 mm) diameter shank, length to suit depth of insulation indicated.
   b. Manufacturers: AGM Industries #CWP-1, GEMCO #CD, Midwest Fasteners #CD, Nelson Stud Welding #TPA/TPC/TPS or equal.
2. Cupped-Head, Capacitor-Discharge-Weld Pins:
   a. Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106 inch (2.6 mm) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38 mm) galvanized carbon-steel washer.
   b. Manufacturers: AGM Industries #CHP-1, GEMCO #Cupped Head Weld Pin, Midwest Fasteners #Cupped Head, Nelson Stud Welding #CHP or equal.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers:
   a. Baseplate welded to projecting spindle capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   c. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum or Stainless steel coordinated with application, fully annealed, 12 gauge, 0.106 inch (2.6 mm) diameter shank, length to suit depth of insulation indicated.

d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
e. Manufacturers: AGM Industries, Inc. #Tactoo Perforated Base Insul-Hangers, GEMCO #Perforated Base, Midwest Fasteners #Spindle or equal.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers:
   a. Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   b. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
   c. Spindle: Nylon, 0.106 inch (2.6 mm) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
   d. Adhesive as recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
   e. Manufacturers: GEMCO #Nylon Hangers, Midwest Fasteners #Nylon Insulation Hangers or equal.
5. Self-Sticking-Base Insulation Hangers:
   a. Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   c. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum, Stainless steel, fully annealed, as coordinated with application. 12 gauge, 0.106 inch (2.6 mm) diameter shank, length to suit depth of insulation indicated.
   d. Adhesive-backed base with a peel-off protective cover.
   e. Manufacturers: AGM Industries, Inc. #Tactoo Self-Adhering Insul-Hangers, GEMCO #Peel & Press, Midwest Fasteners #Self Stick equal.
6. Insulation-Retaining Washers:
   a. Self-locking washers formed from 0.015 inch (0.41 mm) thick, galvanized-steel, aluminum or stainless steel sheet, as coordinated with application with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
   c. Manufacturers: AGM Industries #RC-150, GEMCO #R-150, Midwest Fasteners #WA-150, Nelson Stud Welding #Speed Clips or equal.
7. Nonmetal Insulation-Retaining Washers:
   a. Self-locking washers formed from 0.016 inch (0.41 mm) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   b. Manufacturers: GEMCO, Midwest Fasteners or equal.

C. Staples: Outward-clinching insulation staples, nominal 0.75 inch (19 mm) wide, stainless steel or Monel.

D. Wire: 0.062 inch (1.6 mm) soft-annealed, stainless steel.
   1. Manufacturers: C&F Wire Products or equal.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
   1. Verify that systems and equipment to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature ranging from 140°F to 300°F (60°C to 149°C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
   2. Carbon Steel: Coat carbon steel operating at a service temperature ranging from 32°F to 300°F (0°C to 149°C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.03 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3” (75 mm) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) on center.

3. Overlap jacket longitudinal seams at least 1-1/2” (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2” (50 mm) on center. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4” (100 mm) beyond damaged areas. Adhere, staple, and seal patches like butt joints.

O. For above ambient services, do not install insulation to the following:
1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.04 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
   c. On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16” (400 mm) on center in both directions.
   d. Do not over compress insulation during installation.
   e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
   f. Impale insulation over anchor pins and attach speed washers.
   g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles or breather springs. Place one circumferential girdle around equipment approximately 6” (150 mm) from each end. Install wire or cable between two circumferential girdles 12” (300 mm) on center. Install a wire ring around each end and around outer periphery of center openings and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48” (1200 mm) on center. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3” (75 mm).

8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:
1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6” (150 mm) centers, starting at corners. Install 3/8” (10 mm) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. Fabricate boxes from galvanized steel, aluminum or stainless steel, at least 0.040 inch (1.0 mm) thick.
3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.05 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Boiler Breechings:
1. Secure single-layer insulation with stainless-steel bands at 12” (300 mm) intervals and tighten bands without deforming insulation material.
2. Install two-layer insulation with joints tightly butted and staggered at least 3” (75 mm). Secure inner layer with wire spaced at 12” (300 mm) intervals. Secure outer layer with stainless-steel bands at 12” (300 mm) intervals.
3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1” (25 mm). Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

3.06 INSTALLATION OF PHENOLIC INSULATION

A. Secure single-layer insulation with stainless-steel bands at 12” (300 mm) intervals and tighten bands without deforming insulation materials.

B. Install two-layer insulation with joints tightly butted and staggered at least 3” (75 mm). Secure inner layer with 0.062” (1.6 mm) wire spaced at 12” (300 mm) intervals. Secure outer layer with stainless-steel bands at 12” (300 mm) intervals.

3.07 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
1. Draw jacket smooth and tight to surface with 2” (50 mm) overlap at seams and joints.
2. Embed glass cloth between two 0.062” (1.6 mm) thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:
1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2” (38 mm) laps at longitudinal seams and 3” (75 mm) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1” (25 mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
   1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2” (50 mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12” (300 mm) on center and at end joints.

E. Where PVDC jackets are indicated, install as follows:
   1. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference less than 34” (860 mm). A 34” (860 mm) circumference limit allows for 2” (50 mm) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fish mouthing," and use PVDC tape along lap seal to secure joint.
   2. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 125% circumferences to avoid damage to tape edges.

3.08 FINISHES

A. Equipment Insulation with ASJ+, Glass-Cloth or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 for Sections "Exterior Painting” and “Interior Painting”.
   1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless steel jackets.

3.09 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.

C. TABLE 1: EQUIPMENT INSULATION TYPE REQUIRED.
   1. All insulation thicknesses shall meet or exceed state energy code requirements as noted below. Increase thickness by 1/2” (minimum) where insulated pipe is exposed to exterior ambient air. Minimum thermal resistance shall comply with building code minimum ranges and may exceed those minimum levels. Insulation thicknesses may be adjusted for equivalent insulation values for materials with superior “K” factors. Refer to “PART 2-PRODUCTS” for characteristics of each insulation material listed below.

EQUIIPMENT INSULATION INDEX	
INSULATION KEY CODE	INSULATION TYPE
EI-A	Rigid Hydrous Calcium Silicate
EI-B	Rigid Closed-Cell Cellular Glass
EI-C	Flexible Closed-Cell Elastomeric, Neoprene or Polyethylene
EI-D	Rigid Fiberglass Board
EI-E	Flexible Fiberglass Blanket
EI-F	Rigid High Temperature Mineral Fiber Board
EI-G	Rigid High Temperature Mineral Fiber Blanket
EI-H	Rigid Closed-Cell Phenolic Foam
EI-I	Rigid Closed-Cell Polyisocyanurate Foam
EI-J	Rigid Extruded Polystyrene Foam Board
EI-K	Flexible Low Temperature Aerogel
EI-L	Flexible High Temperature Aerogel
EI-M	Flexible Extreme High Temperature Aerogel

TABLE 1: EQUIPMENT INSULATION TYPE REQUIRED		
SERVICE	INSULATION KEY CODE	THICKNESS/REMARKS (Minimum)
Insulated pipes, equipment, fittings, valves, etc. at pipe hangers and supports with saddles or 360° shields.	**EI-A**	Same thickness as adjoining pipe insulation
Chiller cold surfaces: condenser, evaporator, heat recovery bundles, suction piping, compressor inlets, water boxes, and nozzles.	**EI-C,D,F,H,I**	1” (25 mm)
Heat exchanger for cooling service.	**EI-C,D,F,H,I**	1” (25 mm)
	EI-K	0.6” (15 mm)
Chilled water pump.	**EI-C,D,F,H,I**	1” (25 mm)
	EI-K	0.6” (15 mm)
Condenser water pump (outdoors).	**EI-C,D,F,H,I**	1” (25 mm)
	EI-K	0.6” (15 mm)
Heating hot water pump.	**EI-D,F,H,I**	3” (75 mm)
	EI-L	1.5” (38 mm)
Chilled water expansion/compression tank.	**EI-C,D,E,F,G,H,I**	1” (25 mm)
	EI-K	1/2” (12 mm)
Condenser water expansion/compression tank.	**EI-C,D,E,F,G,H,I**	1” (25 mm)
	EI-K	1/2” (12 mm)
Hot water expansion/compression tank.	**EI-C,D,E,F,G,H,I**	1” (25 mm)
	EI-K	1/2” (12 mm)
Heat recovery system expansion/compression tank.	**EI-C,D,E,F,G,H,I**	1” (25 mm)
	EI-K	1/2” (12 mm)
	EI-C,D,E,F,G,H,I	1” (25 mm)

TABLE 1: EQUIPMENT INSULATION TYPE REQUIRED		
SERVICE	INSULATION KEY CODE	THICKNESS/REMARKS (Minimum)
Insulated pipes, equipment, fittings, valves, etc. at pipe hangers and supports with saddles or 360° shields.	**EI-A**	Same thickness as adjoining pipe insulation
Chilled and condenser water air separator	**EI-K**	0.6” (15 mm)
Heating water air separator.	**EI-C,D,E,F,G,H,I**	3” (75 mm)
	EI-L	1.5” (38 mm)
Cold thermal storage tank (indoors).	**EI-C,D,E,F,G,H,I**	3” (75 mm)
	EI-K	1.5” (38 mm)
Cold thermal storage tank (outdoors).	**EI-H,I,J**	3” (75 mm)
	EI-K	1.5” (75 mm)
Buried cold water piping and tanks.	**EI-B**	2” (50 mm)

3.10 EQUIPMENT INSULATION JACKET SCHEDULE

A. All insulation jackets shall be applied to protect the underlying insulation as scheduled above, providing protection both from environmental and physical conditions.

B. TABLE 2: INDOOR FIELD APPLIED EQUIPMENT INSULATION JACKETS

TABLE 2: INDOOR EQUIPMENT FIELD APPLIED INSULATION JACKET				
SERVICE	JACKET TYPE	THICKNESS OPTIONS	FINISH OPTIONS	CORRUGATION OPTIONS
Concealed equipment.	PVC	20 or 30 mils		
	Aluminum	0.016, 0.020, 0.024 or 0.032 inch	Smooth, corrugated, embossed	
	Stainless Steel	0.010, 0.016, 0.020, 0.024 inch	Smooth, corrugated, embossed	
Exposed equipment up to 48 inches in diameter or with flat surfaces to 72 inches.	PVC	20 or 30 mils		
	Aluminum	0.016, 0.020, 0.024 or 0.032 inch	Smooth, corrugated, embossed	
	Stainless Steel (304 or 316 type)	0.010, 0.016, 0.020, 0.024 inch	Smooth, corrugated, embossed	
Exposed equipment larger than 48 inches in diameter or with flat surfaces greater than 72 inches.	Aluminum	0.032 inch 0.040 inch	Smooth Embossed	1-1/4 inch deep to 2-1/2 inch deep 4 x 1 inch
	Stainless Steel (304 or 316 type)	0.020 inch 0.024 inch	Smooth Embossed	1-1/4 inch deep to 2-1/2 inch deep 4 x 1 inch
Notes: Install jacket over insulation material. For insulation with factory applied jacket, install the field applied jacket over the factory applied jacket. If more than one material is listed, selection from materials listed is Contractor's option.				

C. TABLE 3: OUTDOOR FIELD APPLIED EQUIPMENT INSULATION JACKETS

TABLE 3: OUTDOOR EQUIPMENT FIELD APPLIED INSULATION JACKET				
SERVICE	JACKET TYPE	THICKNESS OPTIONS	FINISH OPTIONS	CORRUGATION OPTIONS
Concealed equipment	PVC	20 or 30 mils		
	Aluminum	0.016 inch, 0.020inch, 0.024inch, 0.032 inch 0.040 inch	Smooth, Corrugated, Embossed	
	Stainless Steel	0.010 inch 0.016 inch 0.020 inch 0.024 inch	Smooth, Corrugated, Embossed	
Exposed equipment up to 48 inches in diameter or with flat surfaces to 72 inches.	Aluminum	0.016, 0.020, 0.024 or 0.032 inch	Smooth, Corrugated, Embossed	
	Stainless Steel (304 or 316 type)	0.010 inch 0.016 inch 0.020 inch 0.024 inch	Smooth, Corrugated, Embossed	
Exposed equipment larger than 48 inches in diameter or with flat surfaces greater than 72 inches.	Aluminum	0.032 inch 0.040 inch	Smooth Embossed	1-1/4 inch deep to 2-1/2 inch deep x 4 x 1 inch
	Stainless Steel (304 or 316 type)	0.020 inch 0.024 inch	Smooth Embossed	1-1/4 inch deep to 2-1/2 inch deep x 4 x 1 inch
Notes: Install jacket over insulation material. For insulation with insulation with factory applied jacket, install the field applied jacket over the factory applied jacket. If more than one material is listed, selection from materials listed is Contractor's option.				

END OF SECTION 23

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Description: Design, furnish, install, and connect analog addressable, intelligent fire alarm and detection system with emergency voice/alarm communication required to form a complete coordinated system ready for operation. It shall include, but not be limited to, initiating devices, alarm notification appliances, control panels, annunciators, auxiliary control devices, power supplies, batteries, wiring and ancillary devices as shown on the Contract Drawings, as specified herein or as required to meet AHJ requirements. Contract Drawings and Specifications indicate minimum system requirements. This is a bidder-designed system and it is the responsibility of the fire alarm system vendor to provide an AHJ approved system and design.

B. General Requirements: Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 sections apply to Work in this section.

1.2 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with applicable city, county, and state codes and ordinances.

B. Authorities Having Jurisdiction (AHJs):
   1. Bothell Fire Department.
   2. State Fire Marshall.
   3. Owner's Fire Insurance Carrier.
   4. University of Washington Bothell

C. Codes and Standards:
   1. NFPA 70, National Electrical Code (NEC).
   2. NFPA 72, National Fire Alarm Code.
   3. UL 268, Standard for Smoke Detectors for Fire Alarm Signaling Systems.
   4. UL 864, Control Units and Accessories for Fire Alarm Systems.
   5. UL 217, Standard for Smoke Alarms.
   6. FM Global.

D. Comply with NEC as applicable to construction and installation of fire alarm and detection system components and accessories. Components and systems UL listed and labeled for fire alarm systems and fire alarm and detection systems and accessories and FM approved. Comply with applicable State and local requirements.

E. Comply with applicable provisions of current NFPA 72, local building codes, and requirements of AHJs.

F. Permits and Fees:
   1. Arrange for inspections and pay for all required licenses, permits, inspections, plan review fees and any other fees.
   2. Submit complete set of fire alarm system submittals to AHJ for approval.

G. Fire Alarm and Detection System Installer Requirements:
   1. The installer shall be an authorized manufacturer's agent staffed with factory-trained and certified sales and service technicians. The installer shall have been the designated manufacturer's representative in the local market for a minimum of five (5) years.
   2. The local office of the installer shall be UL listed under the UUJS or UUFX category as a qualified fire alarm system provider.
   3. The fire alarm system installer shall coordinate the installation of the fire alarm system including the preparation of shop drawings and submittals to the Authority Having Jurisdiction.
   4. System design and preparation of shop drawings shall be by factory-trained personnel with the following qualifications: NICET-certified fire-alarm technician, Level II minimum.
   5. System installation shall be by factory-trained personnel with the following qualifications: NICET certified fire alarm technician, Level II minimum.

6. System commissioning and testing shall be by factory-trained personnel with the following qualifications: NICET certified fire alarm technician, Level II minimum.
7. Contractor's factory trained technical representative shall respond to job site within 24 hour period for emergencies relating to system.
8. Emergency response is defined as having a technician actively troubleshoot and correct problem at job site.

H. Existing Systems: Maintain campus network system operation during construction cutover or provide complete fire watch as required by the local AHJ.

1.3 SUBMITTALS

A. Comply with requirements in Division 01 and Section 260500.

B. Installer Qualifications.

C. Detailed description of equipment anchorage devices on which certification is based and their installation requirements. Sequence of Operation Matrix: Provide a sequence of operation matrix which includes all trouble, supervisory and alarm conditions monitored by the system. The matrix shall be included in the shop drawing set. Provide written sequence of operation that describes the interlocks between the Fire Alarm system and all other building systems (Fire suppression, HVAC, Access Control, etc.).

D. Product Data: Submit manufacturer's technical product data for fire alarm and detection systems components including, but not limited to, roughing-in diagrams and instructions for installation, operation, and maintenance, suitable for inclusion in the Maintenance and Operation Manuals. Include riser and wiring diagrams for panel and system components.

E. Shop Drawings: Indicate equipment and device locations and connecting wiring of entire fire alarm and detection system. Include layout wiring and riser diagrams, point-to-point diagrams, and floor plans with notification appliances, raceways and wiring routing, including device addresses and strobe candela ratings.

F. Details and schedules to include:
1. Battery Calculations.
2. Notification Appliance Circuit Calculations and Loads.
3. Strobe Circuit Voltage Drops.
4. Notification Appliance Circuit Schedules.
5. Symbol Legend and Wiring Code (per manufacturer's requirements).
6. I/O Point and Relay Schedules.
7. Typical Wiring Diagrams indicating connections between panel modules and field devices and auxiliary interfaces (i.e. elevator controls, fire doors, etc.).

G. Acceptance Test Procedure: Submit a written Acceptance Test Procedure (ATP), approved by the AHJ, to Engineer at least thirty days prior to scheduled testing. The ATP shall include step-by-step procedures for performance testing every fire alarm device and system output to demonstrate functionality in accordance with specification requirements.

H. Acoustical Acceptance Test Procedure: Submit a written Test Procedure to be approved by the Owner/Engineer. Test procedure shall identify the different acoustical distinguishable space assignments/classifications and how each will be tested to meet the minimum requirements for Speech Transmission Index (STI) of 0.50 STI. Provide testing equipment documentation.
1. Testing Product Data. Submit technical product data for the sound testing equipment to be used during testing and commissioning. Equipment shall be capable of testing STI and CIS scores using the STIPA Test Signal to 0.01.

I. Test Reports:
1. Field test reports.
2. Acoustical test reports.
3. Submit completed copy of reports and include copy in the Operation and Maintenance Manual.

J. Obtain from each AHJ written certification that the permanent installation has been inspected and that it complies with AHJs' published regulations and requirements. Submit prior to Substantial Completion.

K. Operation and Maintenance Data: Comply with requirements in Section 260500. In addition, include the following:
   1. Prepare complete, simple, understandable, step-by-step, testing instructions with recommended and required testing frequency of equipment with methods for testing equipment. Include trouble-shooting manual.
   2. Prepare complete, easy-to-read, understandable maintenance instructions including the following information:
      a. Instruction on replacing components of system including inspection, periodic preventative maintenance, fault diagnosis, and repair or replacement of defective components.
      b. List of equipment and components with address and phone number of both manufacturer and local supplier of each item.
   3. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
   4. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
   5. Record copy of site-specific software.
   6. Submit minimum one week prior to system training.

L. [Instruction Card: Provide a computer-generated instruction card mounted behind a Lexan plastic or glass cover in a stainless steel or aluminum frame. Card must indicate those steps to be taken by an operator when a signal is received as well as functional operation of system under all conditions: normal, alarm, supervisory, and trouble.]

1.4 SYSTEM DESIGN CRITERIA (BIDDER DESIGN)

A. Design, furnish, and install complete operable fire alarm and detection systems in accordance with the latest adopted editions of IBC, IFC, NFPA 72, and applicable city, county, and state laws, codes, and standards.

B. Drawings reflect minimum Owner requirements. The Contractor's scope of work shall include but not limited to the following:
   1. Complete fire alarm system based on the available architectural, civil, structural, mechanical and electrical drawings.
   2. Wiring systems associated with fire alarm system.
   3. Provide additional smoke detectors, heat detectors, manual alarm stations, horns, visual notification appliances, speaker notification appliances, bells, door holder controls, fire shutter and fire curtain controls, panels, power supplies, and control graphic annunciators associated with fire alarm system.
   4. Provide auxiliary controls and switches including interposing control, monitor relays, and interconnection coordination for monitoring of fire sprinkler system tamper, flow and pressure switches, mechanical equipment shutdown and smoke and combination fire/smoke damper controls, elevator controls, smoke evacuation controls, area pressurization controls.
   5. Audibility and Intelligibility requirements shall meet NFPA 72 and contractor shall provide bypass for any devices near manual microphone stations as required to support audibility and eliminate any feedback on the system.
   6. Complete alerting system connected to the fire alarm system that includes equipment to provide information and instructions to people in buildings or other spaces using intelligible voice communications and including visual signals or other communication methods.

1.5 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning with Substantial Completion, provide software support for two years.

C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1.1 [EXTRA MATERIALS AND LABOR

A. General: Furnish and install additional devices as specified herein. For each device, include rough-in and fifty feet of raceway and wiring extended from local fire alarm circuit. Location of devices as required by authority having jurisdiction [or owner]. Include shop drawing revisions and engineering time to update drawings for resubmittal to AHJ. Turn over any unused devices to the Owner and obtain signed receipt.

1. Smoke detectors: Quantity [fifteen].
2. Duct smoke detectors: Quantity [two].
3. Heat detectors: Quantity [two].
4. Manual pull stations: Quantity [three].
5. Wall mounted strobes: Quantity [five].
6. Ceiling mounted [horn][speaker]/strobes: Quantity [ten].
7. Ceiling mounted strobes: Quantity [five].
8. Wall mounted [horn][speaker]/strobes: Quantity [ten].
9. Detection Loop in fire alarm control panel: Quantity two circuits.
10. Output control loop in panel: Quantity two circuits.
11. Spare capacity on each loop: 25%.
12. Monitor Modules: Quantity [ten].
13. Control Relays: Quantity [fifteen].]

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Fire Alarm and Detection System: Subject to compliance with requirements, Simplex Grinnell. No substitutions.

2.2 FIRE ALARM AND DETECTION SYSTEMS

A. General: Electrically operated, electrically supervised, fire alarm and detection system as described herein. Include control units, power supplies, alarm initiating and indicating devices, conduit, wire, fittings, and accessories required for a complete operating system.

B. Comply with requirements in Section 260533 for raceways, Section 260519 for conductors, Section 260534 for outlet boxes, and Section 260529 for supports. Minimum wire size No. 16 AWG for initiating circuits and No. 14 AWG for indicating circuits.

C. Open cabling methods may be utilized above accessible ceilings. All cabling in exposed areas, above inaccessible ceilings and in walls shall be installed in raceway.

D. Notification Appliance and Signaling Line Circuits: NFPA 72, Class B

1. Install no more than 100 addressable devices on each signaling line circuit. Provide isolation modules on signaling line circuits: 1) on each floor where serving multiple floors, and 2) so no more than 50 addressable devices can be out of service due to a single wiring fault.
2. [Signaling Circuitry: An open circuit in any speaker or strobe circuit shall not prevent the balance of the notification appliance circuits from operating. The control equipment shall supervise the speaker and strobe circuits to detect wiring faults.
3. Selective Signaling: The system shall be configured to allow selective signaling by alarm type as well as by zone, floor, building, or general alarm. It shall also be capable of providing alarm signal to all zones simultaneously.]

2.3 SYSTEM TYPE

A. Low voltage, point identification fire management system. Fire alarm and detection system shall monitor intelligent (analog) and addressable (digital) devices, traditional initiating devices, point identify alarm location, and transmit signals to monitoring agency.

B. Fire alarm control panel shall allow for loading or editing special instructions and operating sequences. System capable of on-site programming to accommodate and facilitate expansion, building parameter changes, and changes as required by AHJs. Software operations stored in non-volatile programmable memory within fire alarm control panel. Loss of primary and secondary power shall not erase instructions stored in memory.

C. Emergency voice communication control panel shall provide for one-way voice communications, routing and pre-amplification of digital alarm tones and voice (digital and analog) messages. Automatic pre-recorded messages and live messages shall be broadcast through speakers. Live messages shall override the automatic messages and tones. Voice messages shall be developed based upon input from AHJ.

D. Autonomous Control units monitor and control the notification appliance network and provide consoles for local operation. Authorized personnel must be able to use a console to initiate delivery of prerecorded voice messages, provide live voice messages and instructions, and initiate visual strobe notification appliances. ACU must override audible fire-alarm notification signals and voice messages based on the approved sequence of operation

2.4 FIRE ALARM NETWORK

A. High Speed Network Communication utilizing multi-mode fiber is existing on campus. Provide network cards and connections to get the new building system tied into the campus network.

1. The high speed network architecture shall be through a token ring, hub, or star topology configuration, or combination thereof. A single open, ground or short on the network communication loop shall not degrade network communications. Token shall be passed in opposite direction to maintain communications throughout all network nodes. At the same time the status of the communication link shall be reported. If a group of nodes becomes isolated from the rest of the network due to multiple fault conditions, that group shall automatically form a sub-network with all common interaction of monitoring and control remaining intact. The network shall be notified with exact details of the lost communications.. A node may be an intelligent Fire Alarm Control Panel, Network Workstation or Network Annunciator.
2. The network shall provide communications for single channel digital voice and telephone as well as panel to panel communications on the same optical fiber network media.
3. The network shall be capable of expansion to at least 99 nodes.
4. Each network shall have the capability of communicating with two node addresses simultaneously.
5. The network shall provide a connection point for network upload/ download of panel application software and panel database configurations while nodes on the network are in service.
6. Network upload/download shall support broadcast and point to point operation.
7. Each network node address shall be capable of storing event equations. The event equations shall be used to activate outputs on one network node from inputs on other network nodes.
8. The Network shall utilize an IP based Ethernet technology.
9. The network shall communicate via fiber optic medium. The Network shall be compatible with multimode and single mode fiber optic media without the use of external converters.
10. The Network shall operate as a Style 7 network.
11. Provide a network interface in every fire alarm control panel.
12. The high speed network interface shall function as a network repeater to increase the fiber optic distance in dB increments stated in this specification.
13. Fiber Optic Network Communication:
    a. Optical fiber cabling in accordance with Section 271100 “Telecommunications System”. Cabling shall meet fire alarm manufacturer requirements.

b. Cabling jumpers shall be dedicated for the fire alarm system.

2.5 SYSTEM OPERATION

A. Alarm displayed on an 80 character alphanumeric display and on remote printer. Top line of characters shall be point label and second line shall be device type identifier. System alarm red LED shall flash on control panel and remote annunciator shall indicate specific device in alarm. Subsequent alarm received from another zone after being acknowledged shall flash system alarm LED on control panel and remote annunciator. LCD display and printer shall show new alarm information. Alarm tone shall occur within control panel and remote annunciator until acknowledged.

B. Alarm indicating devices silenced by entering locked control cabinet and operating alarm silence switch. Subsequent alarm condition shall reactivate signals.

C. Activation of any system smoke detector shall initiate an alarm. Alarm verification operation shall be programmed into the system for future use but not active until approved by AHJ. Alarm verification function: control panel shall reset activated detector and wait for second alarm activation. If, within 1 minute after resetting, second alarm is reported from same or any other smoke detector, system shall process alarm as described previously. Time period for alarm verification reset programmable from 0 to 60 seconds. If no second alarm occurs within alarm verification time window, system shall resume normal operation. Alarm verification shall operate only on smoke detector alarms. Other activated initiating devices process immediately. Alarm verification operation selectable by device, not just by zone. Control panel with capability to display number of times zone or detector has gone into verification mode. Information displayed on control panel and transmitted to remote printer and remote annunciator.

D. Control panel shall have a dedicated supervisory and dedicated trouble condition indicator and acknowledge switch.
   1. Activation of any standpipe or sprinkler valve tamper switch shall activate system supervisory service audible signal and illuminate LED at control panel and remote annunciator. Include differentiation between valve tamper activation and open circuits or ground fault trouble conditions.
   2. Activating acknowledge switch shall silence audible signal while supervisory service LED.
   3. Restoring valve to normal position shall cause supervisory service LED to extinguish thus indicating restoration to normal position.

E. Include manual evacuation switch at control panel to operate systems alarm indicating devices. Other control circuits not activated. True alarm processed as described previously.

F. Alarm, supervisory and trouble conditions displayed on control panel from alphanumeric display, and at remote annunciator. If more than one alarm, supervisory or trouble status is initiated, operator may scroll to display new alarms.

G. Control panel capable of supplying minimum 6 Amps at 24 VDC, filtered and regulated. Power supply expandable to total ampacity required by system. Initial system shall include a minimum of 25% spare capacity.

H. Functions of control panel field programmable.

I. Include connection to fire sprinkler system tamper switches, flow switches and high/low pressure alarm switches. Include connection to tamper switches in exterior vaults and post indicator valves as required.

J. Include elevator fire alarm control.

K. Include connections to Emergency Responder Radio Systems or DAS to monitor alarm and trouble signals. **I**n addition to general alarm and trouble signals, include monitoring points for the following:
   1. Loss of normal AC power supply.
   2. System battery charger(s) failure.
   3. Malfunction of the donor antenna(s).
   4. Failure of active RF-emitting device(s).

5. Low-battery capacity at 70-percent reduction of operating capacity.
6. Active system component malfunction.
7. Malfunction of the communications link between the fire alarm system and the emergency responder radio system

L. Include connection from duct smoke detector relay to fan starter control circuit. Fans shut down on local detection only. Provide interposing relays as required for HVAC shutdown. Coordinate requirements with mechanical contractor and equipment vendor. Include interface relay to control system.

M. Include connection to smoke dampers and combination fire/smoke dampers. Dampers close upon activation of smoke detectors in adjacent areas or adjacent duct detection. Include interface relay.

N. Include fire alarm system power and fire closure signal connection to fire shutters and fire curtains. Shutters close on local detection only. Coordinate requirements with shutter/curtain supplier. Include alarm release signals and coordinate requirements with door hardware supplier for the following:
1. magnetic door holders
2. **[**magnetic door lock release
3. delayed egress door hardware release
4. turnstile release
5. collapsible revolving doors**]**. .

O. Include system output relay for alarm signaling to mechanical control system specified in Division 23.

2.6 POWER REQUIREMENTS

A. Include 120 VAC power from dedicated circuit for each control panel.

B. Include 120 VAC power from dedicated circuit for NAC panels. Maximum of three NAC panels per circuit. Include 120 VAC power from dedicated circuit for fire/smoke dampers. Minimum of one circuit per floor.

C. Include sufficient battery capacity to operate entire system upon loss of primary 120 VAC power in normal supervisory mode for a period of 24 hours with 15 minutes of alarm operation at end of this period. System shall automatically transfer to standby batteries upon power failure. Battery charging and recharging operations shall be automatic.

D. Circuits requiring system operating power shall be 24 VDC. Include individual fuses at control panel.

2.7 EQUIPMENT

A. Fire Alarm Control Panel: Modular construction with solid state microprocessor based electronics with a minimum of 25 percent spare point capacity. Include minimum 80 character minimum alphanumeric display to indicate alarms, supervisory service conditions, and troubles. Provide with a voice status command center for voice evacuation communication with the appropriate quantity of audio control switch modules. Speaker loops shall be individually selectable on a classroom zone vs public area zone basis.

B. Control panel shall include the following:
1. 80 character LCD display.
2. Minimum of 2 indicating appliance circuits.
3. Non-volatile EEPROM memory.
4. Multiple password levels.
5. RS232 port for programming and printer and video display unit input/output.
6. Logic Statements.
7. Time Controls.
8. Sequences.
9. Actions.
10. Reporting of all sensors and zones.
11. Sensitivity setting by sensor (within UL Limits).
12. Alarm verification by point or zone.

13. Enabling and disabling of any system device or function.
14. Ground fault detection on all system devices and inputs.
15. Normal and silent walk tests.
16. Cards, Components, Amplifiers etc. as required to support peripheral devices on the system.

C. Programming:
1. Programming accomplished using a standard IBM compatible computer, either desk or laptop.
2. Resident program stored in non-volatile EEPROM memory.
3. System with capability to store system program on a hard disk for future changes, upgrades, and replacement.
4. Software to allow user to reprogram system points, add system points, add or change point descriptions, and update data file. System output functions field programmable to allow custom operation.

2.8 PERIPHERAL DEVICES

A. Manual Stations: Red with raised white lettering. When station is operated, handle shall lock in protruding manner to facilitate quick visual identification of activated station. Station capable of being reset using a key. Stations which require only a screwdriver for operation not acceptable. **[**Surface mounting boxes where required shall be matching type, steel or diecast aluminum with a red finish.**]**

B. Manual Station Guards: Plastic guards with built-in independent local alarm. Stopper Two or approved. Provide on all manual pull stations unless otherwise noted.

C. Smoke Detectors:
1. General: UL 268 listed and documented compatible with control equipment to which it is connected. Photoelectric type, unless indicated otherwise, with a plug-in base and visual indication of detector actuation. Detectors intelligent, addressable and with capability of alarm verification, sensitivity adjustment by detector, and “maintenance alert” circuitry. Integral addressable module.
2. Duct Smoke Detectors: UL 268A listed.
   a. Capable of operating in air velocity range of 300 to 2,000 feet per minute.
   b. Detectors with approved duct housing for mounting exterior to duct. Weatherproof housing for exterior locations.
   c. Perforated sampling tubes extending across width of duct and end support.
   d. Integral filter system air flow monitor to indicate presence and direction of air flow through detector.
   e. Control modules and relay(s) required for equipment shutdown circuit and connection to control system. Coordinate interface with mechanical equipment and controls.
   f. Where duct smoke detector is installed above a ceiling, include remote indicator lamp and magnet activated test switch mounted on ceiling below unit. Label remote lamp and test switch. Furnish test magnet to Owner.
   g. Nameplate indicating corresponding mechanical equipment name and “supply air” or “return air”, as applicable.
3. Beam Smoke Detectors:
   a. Infrared beam smoke detector including transmitter, receiver and remote control unit. Powered from fire alarm system.
   b. Range to 300 feet.
   c. Control system capable of compensate for dirt accumulation on lenses.
   d. Remote Control Unit: Detector capable of being tested from floor level without use of a ladder. Locate in electrical room or as indicated on Contract Drawings.

D. **[**Combination Carbon Monoxide/Smoke Detectors:

1. General: UL 2075 and UL 268 listed and documented compatible with control equipment to which it is connected. Photoelectric type, unless indicated otherwise, with a plug-in base and visual indication of detector actuation. Detectors intelligent, addressable and with capability of alarm verification, sensitivity adjustment by detector, and “maintenance alert” circuitry. Integral addressable module.**]**

E. Heat Detectors: Addressable, analog thermal detectors. Rate of rise feature accomplished with electronic, dual thermistors. Include built-in test switch and LEDs to indicate alarm condition and polling. Thermal head shall plug-in to base. Heat detector rated for the environment in which it is to be installed (135° typical).

F. Heat Detectors, Weatherproof: Automatic resetting rate of rise type suitable for exterior installation. Include addressable module. Temperature rating as required by the installation, 135° F minimum. Fenwal horizontal Detect-A-Fire Series or approved equal.

G. Primary Notification Appliances: Provide flush mounted combination speaker/strobe Audio/Visual signaling appliances where required. Specific audible and visual characteristics shall be as follows:
   1. Visual Signals: Furnish and install xenon strobes, synchronized in accordance with NFPA 72 chapter 4 and rated to UL 1971 standards. Strobes shall have a fixed candela rating, as follows: provide 15 candela in corridors and other areas up to 20’ x 20’, 75 candela in areas up to 40’ x 40’, and 110 candela in areas up to 50’ x 50’.
   2. Audible Signals: Provide High Fidelity audible signal appliances designed to produce a minimum sound output of 85 dbA at 10’, or 15 dbA above ambient; whichever is greater. Speakers shall have field selectable output tap from 0.5 to 2.0 Watts. Initial circuiting design shall be sized at 1.5 Watts per speaker for base design.
   3. Power Supplies: The power supplies provided for the system shall be capable of powering all notification devices simultaneously with a minimum of 20% spare capacity. Provide power supplies in increments of 8 Amps. Supervision of power supplies shall be integral to the panel. The need for separate monitor modules to supervise power supplies are not acceptable.
   4. Amplifiers: The amplifiers provided for the system shall be **[**24**] [**70**]** Volt 50 watt max output. Amplifiers shall be integral to the panel or in a separate enclosure next to the FACP.
   5. Provide color matched surface mounted back boxes for surface mounted devices.

H. Multiple strobes visible in a single room coordinated to flash simultaneously.

I. Water Flow Switches: Provided by Division 21 and wired by Divisions 26, 27, and 28. Coordinate requirements. Sprinkler Valve Tamper Switches: Provided by Division 21 and wired by Divisions 26, 27, and 28. Coordinate requirements.

2.9 COORDINATE POWER REQUIREMENTS FOR DOOR HOLDERS WITH ARCHITECT AND SECURITY SYSTEM. COULD BE POWERED BY EITHER, BUT NEEDS TO BE IDENTIFIED ACCORDINGLY.

A. Magnetic Door Holders: Provided by Division 08 and wired by Divisions 26, 27, and 28. Holders shall be powered from the fire alarm system. Coordinate requirements.

B. Provide Remote LCD Annunciators. The Fire Department remote annunciator shall have a LCD readout and adjacent building map to direct fire fighters to source of alarm. Wording on map shall reflect information on digital readout. Communication between the main fire alarm control panel and the remote annunciators shall be via an RS232 link. A graphic map shall be provided adjacent to the remote LCD annunciator.

C. Provide Graphic map. The Graphic map is a floor plan representation of the facility with a full color image printed on the reverse side of 10 mil. Polycarbonate Lexan. The printed image shall be laminated to a 1/8” rigid backing with a removable adhesive for future replacement. The graphic map shall be secured in a black (standard) anodized aluminum frame and mounted with a concealed security hanging system to prevent any unauthorized removal. Obtain approval of graphic map from AHJ. Graphic map shall include the following:
   1. Clearly legible room names and numbers for all floors of the building.
   2. Location of the Annunciator indicated with “You are Here” notation.

3. Location of the Fire Alarm Panel.
4. Location of Sprinkler Valve Riser Room (if available).
5. Location of the Mechanical Room.
6. Location of Electrical Room.
7. Locations and zone numbers of Areas of Evacuation Assistance.

D. [Plug strips: Provide switched plug strips in audio racks and podia where indicated. Plug strips shall be connected to the fire alarm system and turn off the audio amplifiers in the space in the event of a fire. Plug strips shall be rack mounted, 15 Amp, with surge suppression, front panel LED indicators, 8 total power outlets with 2 switched, and dry contact control connections. Plug strips shall be Middle Atlantic model PDC-915R-2, or equal.]

OR

E. Documentation Cabinet: Provide cabinet sized so that it can contain all necessary documentation. Cabinet shall be prominently labeled “System Record Documents”.

PART 3 EXECUTION

3.1 INSPECTION

A. General: Verify installation conditions as satisfactory to receive work of this section. Do not install until unsatisfactory conditions are corrected. Beginning work constitutes acceptance of conditions as satisfactory.

3.2 PREPARATION

A. Field Measurements: Field verify locations of new and existing work prior to commencing work of this section.

B. Protection: Protect surrounding areas and surfaces to preclude damage from work of this section.

3.3 INSTALLATION, APPLICATION, ERECTION, AND PERFORMANCE

A. General: Install, apply, erect, and perform the work in accordance with Article “Quality Assurance” provisions, specifications, and manufacturer’s installation instructions and directions. Where these may be in conflict, the more stringent requirements govern.

3.4 FIRE ALARM AND DETECTION SYSTEM INSTALLATION

A. Smoke- or Heat-Detector Spacing:
1. Comply with NFPA 72, “Smoke-Sensing Fire Detectors” Section in the “Initiating Devices” Chapter, for smoke-detector spacing.
2. Comply with NFPA 72, “Heat-Sensing Fire Detectors” Section in the “Initiating Devices” Chapter, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed 30 feet.
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A in NFPA 72.
5. HVAC: Locate detectors not closer than 3 feet from air-supply diffusers or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture.

OR

B. Install system in accordance with the Drawings and this section, applicable codes and manufacturer’s recommendations. Install wiring in compliance with NEC for power and non-power limited fire protective signaling circuits. Upon completion, certify in writing to the Owner and general contractor that system has been installed in compliance with NEC.

C. Duct Smoke Detectors: Comply with IFC, NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.

D. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Install within 12" of sprinkler heads.

E. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

F. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

G. Mounting Heights:
   1. Manual Station: Operating handle approximately 48 inches above floor.
   2. Alarm Signal Devices: Approximately 80 inches above floor to centerline.
   3. Magnetic Door Holders: 78 inches to center line except as noted.

H. Wire:
   1. Per manufacturer's recommendations and as per NEC. Comply with requirements in Section 260519.
   2. Where required, provide wiring in metallic conduit. Comply with requirements in Section 260533.

I. Make conduit and wiring connections to equipment requiring monitoring or control. Including but not limited to sprinkler flow switches, sprinkler valve tamper switches, elevator controller, kitchen hood systems and appropriate air handling equipment.

J. Label junction boxes for fire alarm with minimum 1/4 inch letters: "FIRE ALARM".

K. Test conductors for ground conditions before making final wiring connections. Comply with requirements in Section 260526.

L. Maintain wiring color code throughout installation. Include color code identification in the Operation and Maintenance Manual.

M. Coordinate with appropriate subcontractors for installation of equipment and devices that pertain to other work in the contract.

N. Clean dirt and debris from inside and outside of the fire alarm equipment after completion of installation.

O. Coordinate installation of duct smoke detectors with Division 23 work.

P. Install remote annunciators as indicated on the Drawings and as required by AHJ.

Q. Label all conductors in fire alarm panels, terminal blocks, and large pull boxes. Each conductor shall have a unique and specific designation.

R. All wiring shall be terminated/connected to a device, terminal block, or fire alarm panel. T-Tapping and splicing will not be permitted.

S. Wiring installed in riser conduits shall have strain relief in j-boxes so that cable and connections are maintained and not damaged.

T. Specifier Note: This is to install the RF Subsriber units. Remove reference to the owners monitoring agency if the contractor is purchasing the subscriber unit for the owner.

U. Document cabinet: Mount at the system control unit or an approved location on the protected premises. Provide printed label in document cabinet indicating owner project number.

3.5 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 Section "Door Hardware". Connect hardware and devices to fire-alarm system.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
   1. Smoke dampers in air ducts of designated air-conditioning duct systems.
   2. Alarm-initiating connection to elevator recall system and components.

3. Supervisory connections at valve supervisory switches.
4. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.

C. Supervisory connections at elevator shunt trip breaker.

3.6 MANUFACTURER'S FIELD SERVICES

A. Include services of certified technician to supervise installation, adjustments, final connections, and system testing.

B. Include operations and maintenance instructions for the Owner's representative of devices including trouble shooting procedures.

3.7 FIELD QUALITY CONTROL

A. Check out of and final connections to fire alarm control panel by factory trained technicians in employ of factory authorized franchised dealer for products installed.

B. System, upon completion of installation, checked out, final connections made, and tested to initiating and indicating devices by factory trained technicians in employ of factory franchised dealer for products installed.

C. Test completed fire alarm and detection system **[**and Alerting System**]** in accordance with NFPA 72 in presence of the Owner's representative and the AHJ. Upon completion of successful test, certify in writing to the Owner and general contractor that system has been successfully tested and accepted by the AHJ. Include field test results in the Operation and Maintenance Manual.

D. Acoustical Test procedures shall meet the requirements of IEC 60268-16, NFPA 72 Annex D, and as follows for each acoustical distinguishable space:

1. Average three subsequent results taken at each measuring location. The calculated average value in each space shall be rounded to the nearest five-hundredths (0.05) and reported.
2. Test each type of acoustically different space types within the building. Generate the STIPA test signal with all partitions in place and doors closed.
3. Ensure there are no impulsive ambient noises during the measurements, such as speech. At locations/areas with varying ambient noise conditions, the worst-case STIPA results should be measured.
4. Measure audible levels of alert/alarm tones to confirm it is 15 dB or higher than the ambient sound level.
5. For areas that do not meet 0.5 STI, provide recommendations to add or modify speaker locations to improve the STI test results
6. Variations of STIPA test results should not be more than 0.05 STI at one test position. If variations higher than 0.05 STI are measured, then verify and eliminate the causes of these discrepancies and repeat the measurements.

3.8 TRAINING

A. In addition, factory trained technicians shall demonstrate operation of the complete system and each major component to the Owner. Provide hardware, software, and training to allow Owner to view and change panel programming on site and to view programming remotely.

B. A factory trained representative shall provide (1) 4-hour session to fully instruct the Owner's personnel as to correct operating testing, maintenance and troubleshooting procedures. Video tape this training session and provide copy to Owner for future reference. Schedule training with Owner in writing as least 7 working days in advance of the training date.

3.9 RECORD DRAWINGS

A. See Section 260500 for record drawing information. Accurately identify the final location, addresses and type of each device on drawings. Divisions 26, 27, and 28 Subcontractor shall keep a set of record drawings on site during construction and programming and shall mark-up changes made on

these drawings. Transfer the mark-up information to an AutoCAD 2002-2014 format CAD file at the close of the project. Provide the Owner with the mark-up drawings, a CAD plot and CAD file on disk.

B. Provide a complete printout hard copy of the system program and an electronic backup copy or the site specific software for all future programming needs by authorized manufacturer/distributor per NFPA 72 4,5,2,3.(3).

END OF SECTION