

The University of Chicago

Facilities Services

Facility Standards (FS²)

FS² Orientation and Navigation

Volume I – Introduction and Principles

Volume II - Project Development Processes

Volume III – Design Requirements



TABLE OF CONTENTS

Volume I- Introduction and Principles

- A. Overview
 - 1. Guideline Compliance
 - 2. Process
- B. Economic Impact Program
 - 1. Economic Impact
 - 2. Procurement
- C. Civic Engagement
 - 1. The Community
- D. Stewardship and Heritage Resources
 - 1. Heritage Resources Strategy
 - 2. Historic and Cultural Significance
- E. Sustainability
 - 1. Sustainability Plan
 - 2. Guidelines
- F. Accessibility
 - 1. Intent
- G. Reference Documents
 - 1. Additional References

Volume II- Project Development Processes

- A. Consultant’s Relationship to the University
 - 1. Facilities Services Role
 - 2. Consultant Role
 - 3. Related Roles
- B. Project Development Sequence
 - 1. Overview
 - 2. Project Development Phases
 - a. Program Planning and Project Initiation
 - b. Programming Phase
 - c. Schematic Design Phase
 - d. Design Development Phase
 - e. Construction Document Phase
 - f. Furniture, Fixtures, and Equipment
 - g. Bidding and Negotiation Phase
 - h. Construction Phase
 - i. Project Close-out
 - 3. Special Considerations
 - a. Alternate Project Delivery Methods
 - b. New Product/Manufacturer Process
 - 4. Payment Processes

C. Reviews and Approvals

- 1. Functional Design Reviews
 - a. User/Project Meetings
 - b. SD/DD/CD Phase Reviews
- 2. University Design Reviews
 - a. FS Design Review
 - b. Steering Committee
 - c. Board of Trustees
- 3. University Administrative Reviews
 - a. Accessibility Committee
 - b. Provost Space Committee
- 4. External and Regulatory Reviews
 - a. Government and Regulatory Agency Reviews
 - b. Community Reviews
 - c. Other Resources and Entities
 - d. FS Compliance Guide Matrix

D. Construction Delivery Methods

- 1. Construction Management
 - a. Design /Assist Services
- 2. General Contractor
- 3. Design-Build

TABLE OF CONTENTS

Volume III- General Design Requirements

A. General Design and Construction Requirements

- 1. Introduction
- 2. General Design Requirements
 - a. Owners Project Requirements (OPR)
 - b. Basis of Design (BOD)
- 3. Construction Requirements
 - a. General Conditions of the Construction Agreement
 - b. Site Logistics Plan
 - c. Working in Historic Spaces or Buildings
- 4. References

B. Stewardship and Heritage Resources

- 1. Introduction
- 2. HRS Process and Resources
 - a. HRS Database
 - b. Framework Matrix
- 3. HRS Relationship to Facilities Services
- 4. Project Requirements
- 5. References

C. Sustainability

- 1. Introduction
- 2. Sustainability Process
- 3. Guidelines
 - a. Sustainable Sites
 - b. Water Efficiencies
 - c. Energy
 - d. Materials and Resources
 - e. Health, Comfort and Productivity
 - f. Education and Training
 - g. Innovation

4. Life Cycle Cost Analysis

- a. Study Categories
- b. LCCA Process
- c. Guidelines

5. References

D. Accessibility

- 1. Introduction
- 2. Accessibility Process
 - a. Accessibility Plans
 - b. City of Chicago – Mayor’s Office for Persons with Disabilities (MOPD)
- 3. Requirments
 - a. Walking Surface Requirements
 - b. Ramp Requirements
 - c. Stair Requirements
 - d. Handrail Requirements
 - e. Door and Hardware Requirements
 - f. Drinking Fountain Requirements
 - g. Elevator Requirements
 - h. Wayfinding/Signage Requirements
 - i. Minimum Office Size Requirements
 - j. Parking Requirements
 - k. Construction and Manufacturing Tolerances
 - l. Performance Verification and Measurement
 - m. Mock-up Testing
 - n. Field Observation
 - o. Field Testing
- 4. Accessibility Plus Guidelines
- 5. Accessibility References
- 6. Minimum Lactation Station Guidelines
- 7. Lactation Station References

E. Information Resources

- 1. Introduction
- 2. Resources and Deliverables Process
- 3. References

F. Site, Civil, and Grounds

- 1. Introduction
 - a. Site Survey
 - b. Geotechnical Investigation
 - c.1 Paving: Building Entrances And Plazas
 - c.2 Paving: Parking Lots
 - c.3 Paving: Streets and Drives
 - d. Sidewalks and Pathways
 - e. Site Lighting
 - f. Site Furnishings
 - g. Fences and Gates
 - h. Irrigation
 - i. Climbing Vines
 - j. Landscape and Plantings
 - k.1 Utilities: Storm Drainage
 - k.2 Utilities: Sanitary Sewers
 - k.3 Utilities: Site Electric Distribution
 - k.4 Utilities: Site Water Distribution
 - l. Demolition, Site Clearing and Erosion Control
 - m. Earthwork
- 3. References

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

TABLE OF CONTENTS

G. Utilities Systems

- 1. Introduction
- 2. System Guidelines
 - a. Chilled Water
 - b. Steam and Condensate
 - c. Compressed Air
 - d. Utility Piping Identification
 - e. Vaults for Campus Utilities
- 3. Component Matrix and Guidelines
 - a. PS-1 Direct Buried Steam and Condensate Piping
 - b. PS-2 Steam and Condensate Piping in Tunnels/Vaults
 - c. PS-3 Direct Buried Chilled Water Piping
 - d. PS-4 Chilled Water Piping in Tunnels/Vaults
 - e. CAS-1 Compressed Air System
 - f. VS-1 Valves for Steam and Condensate Piping in Tunnels/Vaults
 - g. VS-2 Valves for Chilled Water Piping in Tunnels/Vaults
 - h. VS-3 Valves for Direct Buried Chilled Water Piping
 - i. TCS-1 Chilled Water Piping Testing and Flushing Guideline
 - j. TS-2 Pressure Test for Compressed Air Piping
 - k. TS-3 Testing of Steam and Condensate Piping
 - l. CS-2 Gas Piping Blow-out and Cleaning
 - m. CS-4 Steam and Condensate Piping Flushing and Cleaning
 - n. IS-1 Steam and Condensate Piping Insulation in Tunnels/Vaults

H. Building Envelope

- 1. Introduction
- 2. Guidelines
 - a. Bird Safety
 - b. Function
 - b.i. Support
 - b.ii. Control
 - b.iii. Finish
 - c. Performance Criteria
 - c.i. Performance Criteria - Support
 - c.ii. Performance Criteria – Control
 - d. Material and Assembly Requirements
 - d.i General Exterior Wall Requirements
 - d.ii Cast-in-Place Concrete Requirements
 - d.iii Precast Concrete Requirements
 - d.iv Masonry Requirements
 - d.v Glass and Glazing Requirements
 - d.vi Glass and Aluminum Curtainwall Requirements
 - d.vii Windows
 - d.viii Doors and Frames
 - d.ix Waterproofing Requirements
 - d.x Roofing Requirements
 - d.xi Exterior Paints and Coatings
 - e. Renovation/ Alterations
 - f. Design Documentation
 - g. Performance Verification & Measurement
 - h. Mockup Testing
 - i. Field Observation
 - j. Field Testing
- 3. References

I. Interior Finishes and Accessories

- 1. Introduction
- 2. Guidelines
 - a. Interior Finish Considerations
 - b. Interior Finish Matrix
 - c. Hardware Standards
 - d. Accessory Standards

J. Vertical Transportation

- 1. Introduction
- 2. System Guidelines
 - a. Traction Elevators
 - b. Hydraulic Elevators
 - c. Machine Roomless Elevators
- 3. Component Guidelines
 - a. Pushbutton Fixtures
 - b. Power Door Operator Equipment
 - c. Traveling Cable Requirements
 - d. Elevator Equipment Room
 - e. Pit and Hoistway
 - f. Cab Interiors
 - g. Emergency Power Operation
 - h. Warranty
- 4. References

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

TABLE OF CONTENTS

K. Mechanical Systems

Preamble

- 1. Purpose
- 2. Principles
- 3. Conclusion

Mechanical System Standards

- 1. Introduction
- 2. Design Reviews
- 3. General Design Requirements
- 4. Plan And Specification Requirements
- 5. System Design Requirements
- 6. Building Mechanical Systems Summary
- 7. Campus Utility System Requirements
 - a. Air Handling Systems
 - b. Exhaust Fans
 - c. Chilled Water Systems
 - d. Ductwork Systems
 - e. Hydronic Piping Systems
 - f. Valves For Chilled Water Systems
 - g. Steam Piping Systems
 - h. Insulation Systems
 - i. Pumps
 - j. Installation
 - k. Domestic Water Systems
 - l. Drainage And Vent Systems
 - m. Plumbing Fixtures
 - n. General Piping
- 3. References

L. Building Automation Systems

- 1. Introduction
- 2. BAS Process
- 3. System Guidelines
 - a. Operator Interface
 - b. Equipment
- 4. References

M. Electrical Systems

- 1. Introduction
- 2. System Guidelines
 - a. New Construction- Temp. Power and Building Service Considerations
 - b. Low-Voltage Electrical Power Conductors And Cables
 - c. Grounding And Bonding For Electrical Systems
 - d. Raceway And Boxes For Electrical Systems
 - e. Identification For Electrical Systems
 - f. Overcurrent Protective Device Coordination
 - g. Electrical Power Monitoring And Control
 - h. Lighting Control Devices
 - i. Low-Voltage Transformers
 - j. Switchgear
 - k. Switchboards
 - l. Panelboards
 - m. Motor Control Centers
 - n. Enclosed Bus Assemblies
 - o. Wiring Devices
 - p. Enclosed Switches And Circuit Breakers
 - q. Variable-Frequency Motor Controllers
 - r. Variable Frequency Driven Motors – Induced Voltage Bearing Current Mitigation Strategies
 - s. Engine Generators

- t. Static Uninterruptible Power Supply
- u. Transfer Switches
- v. Transient-Voltage Suppression for Low-Voltage Electrical Power
- w. Interior Lighting
- x. Exterior Lighting
- y. Emergency Lighting
- 3. References

N. Fire Protection Systems

- 1. Introduction
- 2. Fire Protection Design Process
- 3. System Guidelines
 - a. Fire Alarm System
 - b. Fire Sprinkler System
 - c. Testing and Acceptance
- 4. References

O. Maintenance & Operations Standards (To be developed)

P. FF & E (Hyperlink)

Q. Information Technology Services

- 1. Structured Cabling Specifications (Hyperlink)
- 2. Audio Visual Standards (Hyperlink)

R. Energy and Commissioning

S. Safety & Security (Hyperlink)

T. Environmental Health & Safety (Hyperlink)

U. Risk Management, Audit & Safety (Hyperlink)

X. Indoor Air Quality (IAQ)

VOLUME I - INTRODUCTION AND PRINCIPLES

A) Overview

As an internationally recognized institution of higher education, the University’s mission is to produce a caliber of teaching and research that regularly leads to advances in fields such as medicine, biology, physics, economics, critical theory and public policy. Facilities Services (FS) supports that mission through efforts to maintain and enhance the University campus and environment and provide superior client service to the campus community including faculty, students, staff, neighbors and visitors.

The **Facility Standards (FS)²** document is a performance-based guideline developed to ensure that each project meets the following goals:

- 1. Enrich the identity and purpose of the University
- 2. Learn from our past while being open to rigorous exploration of new ideas
- 3. Respond to the best interests of each particular project
- 4. Promote design excellence
- 5. Consider operational requirements at design inception

1. Guideline Compliance

These standards are intended to guide Consultants and others providing design, engineering and construction services for the University of Chicago. The standards are intended to summarize information that is unique to the University of Chicago either by the specialized nature of the facility or by the requirements of the University in integrating stewardship, design, construction, operations, and maintenance.

These standards are to be followed in addition to all required codes and regulations with which the design must conform. It is recognized that these standards are not universally applicable to every project. These standards do not replace professional design and engineering analyses and may not be used directly as contract specifications. The Consultant shall typically conduct independent evaluations; discuss alternatives and recommendations with

the University’s FS Project Manager and other appropriate FS personnel. Where these standards are in conflict with applicable laws, rules, regulations, codes, and/ or orders, judgments or decrees of Federal, State, Department, City or Local Governments or other applicable governmental authority (laws), the laws shall take precedence. Similarly, to the extent these standards conflict with the agreement entered into between the University and the Consultant (Agreement) or the contract documents as defined by the Agreement, the terms of the Agreement or the contract documents shall govern. In this case, as with all exceptions from the (FS)² document, deviations must be formally identified and approved by the FS Project Manager in writing prior to implementation.

2. Process

These standards are organized to follow the Design and Construction process (pre-design to project close-out). Supporting documents and departmental reference documents are organized by resource, sequence, and systems if applicable.

The standards are to be used as a tool by the contracted Consultant but are not meant to substitute for optimum design solutions. The standards constitute minimum requirements which represent the starting point from which the consultants are expected to reach their own determinations. These standards address areas where the University has specific requirements or where certain materials or systems have been selected to ensure campus-wide consistency. They allow the contracted Consultant to introduce alternative or improved concepts, methods and products.

These standards support the University’s reputation as a leader in promoting state-of-the art design and engineering solutions within the industry. The Consultant should resolve all proposed “experimental” or “innovative” materials or systems within the Design Development phase of the project. The schedule will reflect the tools, testing, metrics and communications necessary to assure the life-cycle performance of the building, system or

architectural feature. Consultants are to become familiar with and are responsible for all sections of the (FS)² document, and are to incorporate the appropriate information early in the design and construction process. The University’s vision on sustainability and universal access are also included in the (FS)² document.

B) Economic Impact Program

The University of Chicago has a strong commitment to the consideration and use of certified Minority Business Enterprises, Women-Owned Business Enterprises, and Disadvantaged Business Enterprises (M/W/DBE) to the greatest extent possible, consistent with University procedures and guidelines. As a community partner, the University embraces an ongoing dialogue to ensure positive involvement with the community.

1. Economic Impact

As part of Facilities Services, the Economic Impact unit is responsible for contract compliance as well as the support of new vendors for Facilities Services. The unit works closely with Procurement and campus project teams; networks extensively with vendors, community-based organizations, and trade organizations to expand the University vendor pool. The unit strongly encourages vendors to apply these goals to all subcontracting tiers, suppliers, and consultants hired or retained by the vendor in performance of any work for Facilities Services. Successful projects aim to exceed participation targets.

2. Procurement

The Procurement unit is the local business center for Facilities Services. The primary purpose of the unit is to provide guidance and compliance review services to all Facilities Services units, as well as other University units outside Facilities involved in operations, building and grounds maintenance, and capital improvements to the University. The FS Procurement unit facilitates, approves, and processes all external purchase requests from Facilities Services employees, including commodities, professional services, and construction contracts.

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

VOLUME I - INTRODUCTION AND PRINCIPLES

C) Civic Engagement

1. The Community

The University of Chicago is an intellectual destination and an economic engine in the region and constitutes one of the largest private employers in Chicago as well as being the largest single employer on Chicago’s South Side. As such, the University is committed to enhancing the quality of life in local neighborhoods by working with community-based organizations to improve area housing, retail, parks, and public facilities. The University’s Office of Civic Engagement (OCE) will assist the Facilities Services department and project teams in facilitating community engagement.

The OCE serves as a liaison between the University and the City of Chicago, Municipal Agencies, local Aldermanic Offices, and the broader community. OCE also partners with Facilities Services in addressing neighbor and community-related issues throughout the project development and construction processes as needed. In conjunction with OCE, the FS Project Manager will assist the Consultant and project team members in all community engagement issues as they arise throughout the project phases.

D) Stewardship and Heritage Resources

1. Heritage Resources Strategy

Four different regulatory designations – Chicago Landmark, Chicago Historic Resources Survey, National Register of Historic Places, and National Historic Landmark – serve to identify, evaluate, and protect architectural and historic resources. The Chicago Department of Planning and Development (DPD) reviews all permits for work involving designated and proposed Chicago landmarks and landmark districts. Through the Planned Development zoning designations that encompass the University, DPD conducts additional reviews related to heritage resources especially as to certain properties identified in the Chicago Historic Resources Survey.

2. Historic and Cultural Significance

Historic and Cultural Significance Questions to preserve, restore, renovate or repurpose are significant in the planning and design process. Potential historic and cultural significance should be evaluated alongside meeting campus needs. True historical and cultural significance may be memorialized either in active use, protection in place or by recording the impact of the notable history of quality architectural and academic achievements.

E) Sustainability

1. Sustainability Plan

The University has committed itself to a holistic implementation of goals through the Strategic Sustainability Plan. The University has developed the (FS)² sustainability guidelines for all future facility projects according to this plan. At the University, “sustainable buildings” refer to buildings that use energy, water, and other resources efficiently while providing a safe and productive indoor environment.

2. Guidelines

These guidelines outline an integrated or “whole building” design approach. The process steps are identified to set performance goals and to ensure that decisions are made in a collaborative and informed manner. The maximum benefits to these efforts can be achieved when sustainability is considered in the early phases of the project delivery process. Generally, the University expects that every project preliminarily examine ways to implement sustainable features and incorporate a LEED checklist compliant design review into the beginning of the design process. Larger projects (new buildings over \$5 million in construction costs) must achieve a minimum of LEED Silver certification. The University will determine, on a case by case basis, if higher levels of LEED certification are feasible and appropriate.

F) Accessibility

1. Intent

The University of Chicago is committed to the best practices of accessibility and universal design in the design, construction, alteration and repair of spaces for use or occupancy by University faculty, other academic personnel, students, staff and the public. Here accessibility is meant in the broader sense associated with the concept of “universal design”, including access for both the able-bodied and physically disabled. In support of this commitment, these standards establish requirements that in some cases provide for greater accessibility and ease of use than the requirements of federal, state and local regulations. In the event of differences regarding requirements and standards, the Consultant will be expected to review the best accessibility application for the project with the University. Each project phase will also include initiatives intended to increase compliance with accessibility requirements and objectives by integrating quality assurance measures into the project- beginning with the programming and design process through project closeout. Verification and measurement of completed work will be required. Construction elements found to be nonconforming with these requirements will not be acceptable and must be corrected.

G) Reference Documents

1. Additional References

The University has developed a number of planning and resource documents over time that may be referenced in supplementing the Consultant’s understanding of their project requirements. Examples are:

- Campus masterplans
- Building assessments
- Utility infrastructure plans
- Historical documents

The Facilities Services Project Manager will assist the Consultant in determining the specific project need.

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

VOLUME II - PROJECT DEVELOPMENT PROCESSES

INTRODUCTION

This section outlines the procedures that are expected of capital projects at The University of Chicago. These requirements supplement the planning procedures required by the City of Chicago and all regulatory agencies with jurisdiction on Facilities Services Capital Project Delivery projects. The information described in this section is supplemental to the A/E Agreement and Exhibits; in the case of any conflict, the A/E Agreement shall govern.

The purpose of this section is to:

- Delineate the working relationship, responsibilities, and operational details between The University of Chicago (University) and those Architects, Engineers, and other professionals commissioned by the University for its planning, design, construction and maintenance projects (Consultants). In the event of a conflict between the standards and the terms of the Agreement of the contract documents, the terms of the Agreement or the contract documents shall govern.
- Encourage clear communications and professional attitudes resulting in superior projects.

The design and construction of all projects for The University of Chicago will normally be guided by the following objectives:

- Develop design solutions that comply with the program scope, budget, and schedule as included in the program documents. The project program documents and project requirements will be evaluated throughout the project’s development and construction and serve as a benchmark for performance. The Consultant is required to notify the project team of any proposed divergence from this document and obtain written approval from the University Project Manager before incorporating that divergence into the project. The Consultant will be required to submit a matrix to the University Project Manager documenting the status of each proposed divergence at each project milestone.
- Obtain economic balance, commensurate with available funds and design objectives, between initial construction costs, building permanence, operation, and maintenance costs. The University, within our Stewardship and Sustainability programs, will require project evaluation during the design phase regarding the life cycle profile of the building envelope and major systems performance of the building.
- Incorporate maintainability, energy efficiency and sustainability into the design solution.
- Comply with all applicable codes, including but not limited to those pertaining to accessibility, environmental conditions and safety, and the requirements of participating governmental agencies.
- Exceed current accessibility requirements where feasible as described in these standards, and apply these standards for accessibility to projects for University facilities and sites even where codes and regulations do not require accessibility.
- Meet all defined review and authorization procedures at each phase of the project and provide the required deliverables at each stage and at the conclusion of the project per the FS Compliance Guide Matrix.
- Deliver documentation and training required to support the operation and maintenance of the completed project through its life cycle.

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

A) CONSULTANT’S RELATIONSHIP TO

THE UNIVERSITY

1. Facilities Services Role

The University’s projects are managed through the office of Facilities Services (FS), typically within the Capital Project Delivery (CPD) group. A Project Manager is assigned as the University representative for each project. The FS Project Manager is the sole point of contact for the Consultant and all project correspondence and decisions shall be coordinated through this representative. In order to maximize continuity and accountability the assigned Project Manager will typically be on the project from conception to beneficial occupancy. The Facilities Services department is structured so that as projects move from design into construction the Project Manager reports to senior leadership throughout all project phases, maximizing efficiency, specialized experience, and synthesis with appropriate University resources. An FS organizational chart can be accessed through the FS website to help illustrate the various components of the department.

2. Consultant’s Role

The Consultant will work through the FS project manager, and must turn to this person for authoritative information on all matters and questions involving the University. The Consultant shall designate an individual within the Consultant’s firm who is directly responsible for the project, and who can be contacted directly on any matter pertaining to the project.

3. Related Roles

Additional resources and entities may be required as part of the University’s project deliveryprocess, such as Commissioning Agents, Construction Managers, General Contractors, and various other Owner Consultants. The Consultant is expected to work with those entitiesengaged by the University as necessary throughout the design and construction process.

B) PROJECT DEVELOPMENT SEQUENCE

1. OVERVIEW

The Facilities Services Capital Project Delivery Unit has developed the following processes to assess and implement capital projects and enhance the department’s accountability, responsiveness, efficiency and collaboration with our internal stakeholders and our consultants and design professionals. In addition, the Consultant is advised to review individual standards sections, such as Accessibility, for specific processes inherent within that subject.

FS²: The Project Development Process: Implementation

The purpose of the process is to provide a reliable, repeatable framework for the successful delivery of projects of any size. The process can be tailored to relevantly address the needs of a variety of project types and sizes. FS² is at its core a reference which allows the user, consultant/contractor or staff member, direct access to project-relevant content including process.

Understanding the FS² Project Development Process:

Two Examples (See Figure 2A.01):

For Traditional Projects, which are large and complex, it is expected that the full scope of the Project Development Process as defined in FS2 be employed. Typically each project, beginning with Project Initiation through Close out, will follow the prescribed steps as outlined in Volume II. Compressed Schedule Projects, which make up more than 80% of projects on campus, can be structured to take advantage of compression opportunities. For example, the Schematic design (SD) and Design Development (DD) phases can be combined into a single phase. It should be understood that the process is adaptable suit the particular needs of a given project. Modifications to the process will be established and agreed to at the beginning of a project.

2. PROJECT DEVELOPMENT PHASES

a. Program Planning and Project Initiation

(Prior to Consultant Engagement)

The FS Project Manager is typically identified and assigned to a project upon the initial identification of a facility need by an academic group, school, department, institute, or support function at the University. The project is reviewed at several leadership levels to ensure that it is consistent with the goals, objectives, and priorities of the University. The assigned FS Project Manager will then develop the project charter, including known scope and program requirements. The Consultant will develop the Owner’s Project Requirements (OPR) upon engagement.

Compressed Schedule Projects:

It is at this point that a Compressed Schedule Project will be identified by the FS Project Manager, described in the OPR and an appropriate schedule of phases developed in cooperation with the Consultant and the Consultant’s initiation of the Basis of Design. Additionally, the FS Project Manager will determine the appropriate Construction Document deliverables for the Compressed Schedule Project.

i. Project Management System

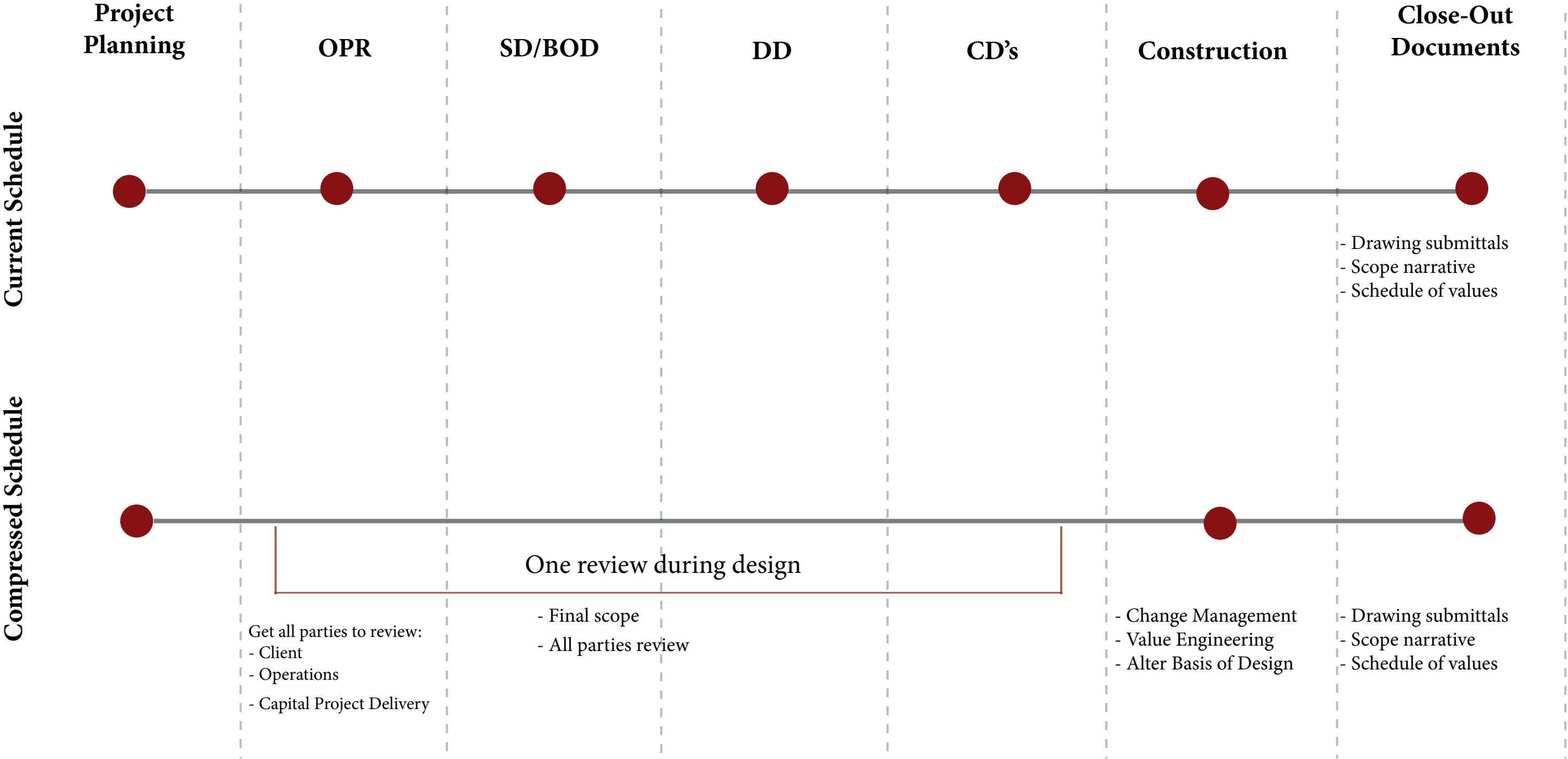
The University maintains a web-based project management system (e- Builder) that enables the team to correspond and document the project throughout the programming, design, and construction phases. Typically, all project correspondence, such as minutes, invoices, RFI’s, etc., will be posted, reviewed, or approved on the system. Any Consultant who has not been previously trained will be expected to attend the next available monthly training session and is welcome to attend additional sessions as a refresher. The Contractor, Commissioning Agent and any other primary vendors on the project will also utilize the University’s projectmanagement software.

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

VOLUME II - PROJECT DEVELOPMENT PROCESSES

TABLE 2A.01 - FS PROJECT DEVELOPMENT PROCESS

The phases outlined in this project workflow diagram may be compressed as applicable for specific projects.



The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

b. Programming Phase

The Programming Phase typically is the start of the Consultant’s engagement, although in some cases, the University will combine the following activities into the Schematic Design Phase. (Refer also to Exhibit A of the A/E Agreement).

i. Schedule

At the beginning of the engagement, the Consultant will be expected to develop and submit a project schedule for the preconstruction phase of the project that outlines key deliverables, milestones and decision points for review with the Facilities Services Project Manager. The Consultant will be expected to update the schedule no less frequently than at the end of each phase. It is very important that the Consultant clearly communicate decision points and expectations at these points, as well as providing adequate time for the University’s team to review and respond to the information provided.

Compressed Schedule Projects:

For those projects identified as Compressed Schedule Projects, the Programming Phases the FS Project Manager may decide to combine this phase with the “Design Phase” (Schematic and Design Development Phases Combined)

ii. Programming, Program Verification, and Conceptual Design

The University will typically require the assistance of the Consultant in program verification of the proposed project, and may require full programming or conceptual design services depending on the nature of the project. The scope of these services will have been established during the Consultant selection.

iii. Site and or Existing Conditions

The University has extensive electronic archives including record drawings for use by the Consultant. However, due to the age of many of the University’s buildings and the many renovations and repairs, these drawings are not always available or may not be updated. It is the responsibility of the Consultant to verify all information provided for accuracy relevant to the Project. The FS

Project Manager is to be notified when any information regarding the existing conditions of a project is inaccurate or inadequate.

The Consultant and FS Project Manager will meet to discuss the processes, Project Directory, and available reference materials and resources within the Facility Services group and University support units such as Information Technology Services (IT Services), Safety & Security, and Environmental Health & Safety (EH&S). The Facilities Services Department includes the Engineering and Utilities managers and the Space Information Management Services (SIMS) group for a point of contact for existing documents including internal and external contacts with utility companies. The University expects the Consultant to perform a thorough examination of existing systems including but not limited to mechanical, plumbing, electrical, and fire protection. As example, the Consultant should not assume that existing HVAC systems are delivering proper air flow to an existing space. If available, the Consultant will be provided with an existing, recent test and balance report. If not available, the Consultant should perform a test and balance as part of the analysis of existing conditions. The electrical engineer is expected to examine existing electrical panels to confirm adequate capacity for the proposed work. Additionally, the Consultant needs to identify any and all areas and concealed spaces (reasonably accessible) that will require assistance from the University in order to get access.

Given the complexity of the utility infrastructure and the importance of the landscape on the University of Chicago’s campus, it is critical that a surface feature conditions survey be completed by the programming or schematic design phase.

iv. Geotechnical information

As part of the Consultant’s services to the University, the Consultant is to recommend a list of qualified, licensed geotechnical service firms that can provide all geotechnical information for projects requiring such services. The University and Consultant will come to consensus on a list of qualified firms to solicit proposals

from. The Consultant shall prepare a scope of services that the University will use in developing the RFP for geotechnical services. The geotechnical consultant shall contract directly with the University, but still be obligated to coordinate its services with the Consultant.

v. Initiation of the Basis of Design.

The Consultant will lead the development of the Basis of Design (BOD) document, informed by completion of due diligence and in response to the overall project goals, budget, and schedule included within the Owner Project Requirements (OPR). This process should include a commissioning and sustainability workshop when appropriate. Compressed Schedule Projects will still be required to submit a Basis of Design even if the Schematic Design and Design Development Phases are combined into a common “Design Phase.”

vi. Kick-off Meeting

The FS Project Manager will hold an initial or kick-off meeting to review the project goals and objectives, communication process, project processes and procedures and to clearly define the project scope, schedule budget (cost), quality and overall project goals. The Consultant is expected to document initial as well as subsequent meetings. Key activities include:

- Engage key stakeholders, set calendar invitations
- Create project directory and communication process
- Define scope, schedule and budget guidelines
- Review overall project goals and OPR/BOD process
- Review Heritage Strategy if applicable
- Review of quality expectations including expectations for inspection of existing conditions
- Review availability of University document resources
- Review of Project Team evaluation process, evaluations will be conducted at set intervals throughout the project
- Review project completion expectations
- Review of FS Compliance Guide requirements

c. Schematic Design (SD) Phase

In the Schematic Design Phase the Consultant shall provide services and deliverables necessary to illustrate the general scope, scale and relationship of project components and systems in alignment with the budget and schedule (Refer also to Exhibit A of the A/E Agreement).

Compressed Schedule Projects: At the beginning of the Project Initiation, the FS Project Manager may decide to combine this phase with or separate from the Programming Phase or combine this phase with the Design Development Phase, in which case the combined phase would meet the requirements of the Design Development Phase as set forth in this document. A Basis of Design will still be required from the Consultant.

i. Schematic Design Start

The FS Project Manager will provide feedback from the project stakeholders and Facility Services leadership at the beginning of the phase to review the program, modify or re-affirm the project requirements, and establish subsequent meetings to develop the proposed project design. The Project Manager will provide written authorization to commence the SD phase if a prior Programming phase has been undertaken. Refer to the Reviews and Approvals section for the various types of meetings and reviews throughout the phase.

ii. Schematic Design (SD) Phase Review

The SD Review Submittal documents shall be reviewed at the end of the SD phase. Refer to the Reviews and Approvals section for a detailed description of the SD Phase Review process.

iii. Schematic Design Review Submittal

The SD Review Submittal to the University consists of a minimum of three (3) complete sets of documents, or as requested by the FS Project Manager. The University will review the documents for completion prior to submission to other review agencies. The SD Review Submittal should be developed to an adequate level of detail to assure that substantive changes will not be required during further development of the drawings to

meet the program, budget and schedule for the project. This includes assuring that the level of development of the MEP and structural systems is adequate to avoid substantive changes to the floor plans, ceiling heights, program, budget and schedule. SD deliverables typically will have been established as part of the contract exhibits, but the following information must also be provided by the Consultant:

- A Basis Of Design (BOD) and Owner’s Project Requirements (OPR) document prepared by Consultant
- An Accessibility Plan as described in the Accessibility section of the standards
- A LEED Checklist with Commentary and Life Cycle Systems evaluation (if applicable)
- Heritage Strategy report as applicable
- Room Name, Numbering, and Areas Consultants should not be compensated at the end of each phase AND the next phase should not proceed without milestone deliverables completed (or director’s sign-off).

d. Design Development (DD) Phase

Based on the approved Schematic Design submittal, the Consultant shall provide services and deliverables necessary to more fully illustrate the project scope (Refer also to Exhibit A of the A/E Agreement). The Design Development deliverables should provide sufficient detail on the project to describe aesthetic and functional descriptions of the program, envelope, structure, mechanical, electrical, plumbing and other systems, in alignment with the budget and schedule.

Compressed Schedule Projects: At the beginning of the Project Initiation, the FS Project Manager may decide to combine this phase with the Design Development Phase, in which case the combined phase would meet the requirements of the Design Development Phase as set forth in this document.

i. Design Development Start

The FS Project Manager will provide feedback from the project stakeholders and Facility Services leadership at the beginning of the phase to review the program, modify or re-affirm the project requirements, and establish subsequent meetings to further develop the project design. Refer to the Reviews and Approvals section for the various types of meetings and reviews throughout the phase.

ii. Design Development (DD) Phase Review

The DD Review Submittal documents shall be reviewed at the end of the DD phase. Refer to the Reviews and Approvals section for a detailed description of the DD Phase Review process.

iii. Design Development Review – FM Global

The DD Review conducted by FM Global shall be coordinated by the FS Project Manager. Together with the University’s Risk Management, the FS Project Manager will determine the project requirements for such reviews.

iv. Design Development Review Submittal

The DD Review Submittal to the University consists of a minimum of three (3) complete sets of documents, or as requested by the FS Project Manager. The University will review the documents prior to any submission to any regulatory agencies with deliverables as required by the contract. In addition to the DD deliverables required as part of the contract, the following information must also be provided by the Consultant:

- An updated Basis of Design (BOD) and Owner’s Project Requirements (OPR) document prepared by Consultant.
- An Accessibility Plan as described in the Accessibility standards
- A LEED Checklist with Commentary and Life Cycle Systems evaluation if applicable
- Commissioning Plan from Cx Consultant
- Consultant is to identify in the bid documents a list of potential service interruptions and disruptions around the areas of work that the General Contractor is to include in their logistics plan and construction schedule.
Examples may include:
 - Utilities: water, power, chilled water shut downs
 - Accessibility in and around the areas of work
 - Noise generating activities and vibrations that may disrupt adjacent spaces
 - Life-Safety including egress & access, fire protection systems
- Review of the Site logistics/utility plans including access routing as prepared by the Contractor.



Consultants should not be compensated at the end of each phase AND the next phase should not proceed without milestone deliverables completed (or director’s sign-off).

e. Construction Document (CD) Phase

Based upon the approved Design Development submittal, the Consultant shall prepare construction documents and other materials required under their contract for the receipt of bids on the project (Refer also to Exhibit A of the A/E Agreement).

Compressed Schedule Projects: For Compressed Schedule Projects, the FS Project Manager in cooperation with the Consultant will determine the appropriate deliverables including abbreviated documents, phased documents, permitting documents or other as may be appropriate for the specific project.

Construction Documentation Start

The FS Project Manager will establish meetings as required to further document the project design. Refer to section on Reviews and Approvals for the various types of meetings, reviews and approvals, including approvals by Regulatory Agencies. Based upon the understanding of the requirements of Regulatory Agencies having jurisdiction on the project, the Consultant will provide support and any documents involving phasing, preliminary review of project by review agencies or other construction enabling efforts, including Permit Documents.

ii. Construction Document (CD) Phase Reviews

The CD Review Submittal documents shall be reviewed at 50% on larger projects and at 90% of the CD phase on all projects. Refer to the Reviews and Approvals section for a detailed description of the CD Phase Review process.

iii. Construction Documents 50% Review Submittal

The CD 50% Review Submittal to the University consists of a minimum of three (3) complete sets of documents, or as requested by the FS Project Manager. The University will review the documents prior to submittal to regulatory agencies. Elements or systems within the project which are to be performance-based must be approved within the Design Development phase. In addition to the CD deliverables required as part of the contract, the following information must also be provided by the Consultant:

- An updated Basis of Design (BOD) and Owner’s Project Requirements (OPR) document prepared by the Consultant.
- An Accessibility Plan as described in the Accessibility section of the standards
- An updated A LEED Checklist with Commentary prepared by the Consultant
- Any updated Life Cycle Cost Analysis reports

iv. Construction Documents 90% Review Submittal

The CD 90% Review Submittal to the University consists of a minimum of three (3) complete sets of documents, or as requested by the FS Project Manager. The University will review the documents prior to submittal to regulatory agencies. The construction documents must be fully engineered and detailed by the Consultant team and not leave project detailing to the shop drawing phase. The construction document set (drawings and written specifications) shall be formatted consistent with standards of practice and requirements of the University and regulatory agencies. In addition to the CD deliverables required as part of the contract, the following information must also be provided:

- An Accessibility Plan as described in the Accessibility section of the standards
- An updated A LEED Checklist prepared by the Consultant
- Heritage Strategy documentation prepared by the Consultant
- M-V program from Cx Consultant
- A Site Logistics Plan if applicable, to be reviewed by the Consultant, prepared by the Contractor.



Consultants should not be compensated at the end of each phase AND the next phase should not proceed without milestone deliverables completed (or director’s sign-off).

VOLUME II - PROJECT DEVELOPMENT PROCESSES

f. Furniture, Fixtures, & Equipment (FF&E)

The project scope may entail design, selection, and coordination of furniture, fixtures, and equipment (FF&E), either existing to be relocated or new. The FS Project Manager will advise the Consultant in coordinating with the appropriate FS furniture vendor representative(s) as well as participating furniture vendor(s) in the University’s Master Furniture Standards program.

g. Bidding and Negotiation Phase

The Consultant’s bidding phase responsibilities in regard to advertising for bids, creation of bid documents and supplementary bid documents, review and evaluation of bids and any exceptions, alternates, or substitutions, shall conform to the requirements of their contract, and include requests for information and preparation of addenda.

i. Preparation for the Bid Phase

Preparation for the bid phase begins in the Construction Documents phase. This includes activities such as the review of prequalified lists of vendors and contractors, development of the bidder list, scheduling of pre-bid conferences, etc. It also includes scheduling of post-bid activities such as detailed bidder scope review meetings to avoid delays in scheduling those meetings after bids have been received.

ii. Pre Bid Conference

The Pre-Bid Conferences are arranged at the convenience of the Consultant and the FS Project Manager.

iii. Bid Openings

The bids will be submitted via e-Builder for tabulation and review. The Project Manager and Consultant will evaluate the bids and comment on the base bid, options, alternates, and bid exceptions or qualifications.

iv. Construction Service Negotiations

The Consultant will participate in a detailed scope review meeting of the most competitive contractors’ proposed team, costs, schedule, approach to the project and other criteria identified in the bid phase. The number of contractors invited to participate in a scope review meeting will be determined by the University based on the bid results.

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

h. Construction Phase

The Consultant’s construction phase responsibilities in regard to submittal reviews, siteobservations, requests for information, changes in the work, alternates or substitutions, certificates of payment, and substantial completion shall conform to the requirements of their contract.

Compressed Schedule Projects: For compressed Schedule Projects the FS Project Manager, at project initiation in cooperation with the Consultant, determine that a phased construction schedule in conjunction with the compressed schedule is to be included in the project delivery. Additionally, the FS Project Manager may require that post-design project valuation (or “value engineering”) be reviewed by the primary users that were involved in the project design prior to acceptance by the University.

i. Issued for Construction Set

The Consultant will prepare an Issued for Construction set of documents to include all updated bidding information, decisions, permit review corrections, etc. prior to start of construction.

ii. Owner, Architect, Contractor (OAC) Kick-off Meeting

The Contractor or Construction Manager will hold an initial OAC kick-off meeting to review project scope, construction schedule, responsibilities, and expectations with the project team. The Contractor is expected to document initial as well as subsequent meetings. Key activities include:

- Distribution of Project Directory
- Review of team member responsibilities
- Review of project scope, schedule, and construction budget
- Review of project procedures, distribution and communication requirements in conjunction with the University’s web-based project management and delivery system (e-Builder)
- Review of anticipated shut-downs, service interruptions, and general disruptions
- Review of sustainability requirements
- Review of project completion expectations
- Review of expected FS Compliance Guide deliverables

iii. Construction Administration (CA)

The Consultant will perform CA duties in conformance with the requirements of their contract throughout the course of construction. The Consultant will be expected to work in a highly collaborative manner with the Contractor, Commissioning Agent, QA/QC Consultants, FF&E vendors, and other University representatives and consultants associated with the project. Key Consultant responsibilities include:

- Submittal review within agreed timeframes
- Request for Information (RFI) responses within agreed timeframes
- Issuance of Architect’s Supplemental Information (ASI) documents
- Change Order (CO) review within agreed timeframes
- Field observation
- Monitoring and updating sustainability compliance as required
- Monitoring and updating accessibility compliance as required
- Contractor’s Payment Application review
- In addition, the Consultant should be aware of deliverable due dates throughout the Construction phase required by the Information Resources standards.

iv. Commissioning

The University will typically engage commissioning services for projects. The Commissioning Agent will coordinate the commissioning requirements for the project with the project team. The University expects that commissioning is complete prior to substantial completion to assure that the building is in working order when occupied and that the University operations staff have been properly trained and prepared to maintain the building. The University understands that certain off-season commissioning will not be complete on certain projects. A commissioning plan should be developed and agreed to with the University prior to issuing documents for bid. In support of this effort the Contractor is to be required to submit all Operations and Maintenance

documentation to the Consultant for review prior to submission of the 50% complete pay request. The Consultant and Commissioning Agent are expected to review and comment in a timely manner to assure that the approved documentation can be submitted to the University Operations staff for review prior to training. Training is to be completed prior to substantial completion. The Commissioning Agent is required to develop a comprehensive training plan for review and approval by the University Operations staff.

v. Punchlist

The Contractor is to prepare a preliminary punchlist based on inspections from the Consultant and project team, including any above-ceiling inspections.

vi. Certificate of Occupancy and Substantial Completion

The Contractor will coordinate final inspections and applications for a Certificate of Occupancy with the FS Project Manager and project team. The Consultant will prepare the Substantial Completion document and attach final punchlist for acceptance by FS Project Manager.

vii. Move Management

The University’s Project Manager and /or User will coordinate User move and occupancy, including scheduling, communications, and FF&E deliveries. The Consultant may be included in the coordination of these issues as required by the project scope and contract.

viii. Construction Phase: Summary expected of FS Compliance Guide deliverables:

- The FS Project Manager will expect as a minimum the following :
- Construction wayfinding and polyline graphic description of accessible routes
 - A QA/QC review of the project process
 - An updated LEED Checklist prepared by Consultant
 - Room number samples
 - Review of updated Site logistics/Utility plans by Consultant as prepared by Contractor



Consultants should not be compensated at the end of each phase AND the next phase should not proceed without milestone deliverables completed (or director’s sign-off).

VOLUME II - PROJECT DEVELOPMENT PROCESSES

i. Project Close-out

The FS Project Manager and Contractor will typically coordinate aspects of the project close-out with the remainder of the project team. The various responsibilities include:

- The Contractor is to complete remaining punch list items (Consultant is responsible for prompt review of completed punch list items)
- The Consultant is to submit remaining applicable deliverables as described in Volume III E. Information Resources to the FS department and prepare Certificate of Final Completion

An eleven (11) month warranty walk-through is to be scheduled as part of the commissioning process. The Consultant, Commissioning Agent and Contractor are expected to attend the walkthrough.

i. Project Close-out: Summary expected of FS Compliance Guide deliverables:

The FS Project Manager will expect as a minimum the following prior to final pay out:

- An updated LEED Checklist prepared by the Consultant
- Consultant review of close out documents for completeness (as prepared by Contractor)
- CADD/BIM as-built documents
- Consultant review of Scope Schedule of Values for completeness (as prepared by Contractor)
- Project Charter Update



Consultants should not be compensated at the end of each phase AND the next phase should not proceed without milestone deliverables completed (or director’s sign-off).

3. SPECIAL CONSIDERATIONS

a. Alternate Project Delivery Methods

Certain University projects will require alternate or phased methods of project delivery. Determination of these requirements should be established as part of the Owner’s Project Requirements at project initiation. For example, consideration may need to be given to phasing occupancy of the project, with associated noise mitigation and staging requirements. Project construction may also require alternate shift schedules to perform construction work around sensitive areas or departments. The FS Project Manager will discuss any special requirements or considerations regarding the design or construction phase.

b. New Product/ Manufacturer Processes

The standards developed by the University FS Department are a result of experience with methods and materials over time, and in some cases, are specific to the campus. However, the University will consider new products or manufacturer processes that have recently been developed for use on projects. In these situations, the Consultant will submit appropriate information, test results, documentation, etc., to the FS Project Manager for consideration. The Project Manager will coordinate an internal review of the submittal and advise the Consultant of the decision in writing. Sufficient time must be allowed for the review process.

4. PAYMENT PROCESSES

The University maintains a web-based project management and delivery system (e- Builder) that enables the team to correspond and document the project throughout the planning, design, and construction phases. Applications for payment are also submitted, reviewed, and approved through this process. The FS Project Manager or financial analyst will coordinate contract information set-up in the system and the Consultant will subsequently submit invoices according to their contract requirements.

C) REVIEWS AND APPROVALS

The Consultant is expected to participate in presentations, review conferences, and make submittals at various stages of the project planning and construction process. Expected project phase submittals/deliverables are summarized in the FS Compliance Guide Matrix.

1. FUNCTIONAL DESIGN REVIEWS

a. User /Project Meetings

The University department(s), or Users, that will occupy the building will have representatives attending regular project meetings as determined by the FS Project Manager to meet the project needs. They will also participate in periodic reviews, milestone reviews, and may have representatives serving on a Steering or other Committees if the scale, scope and complexity of the project require such.

b) SD/DD/CD Phase Reviews

The Facility Services Department includes Operations, Capital Project Delivery (CPD), Procurement and Economic Impact, Campus Planning & Sustainability, Engineering & Utilities representatives, each of which will participate as necessary in the project phase reviews at various milestones in the project development. Other administrative support units, such as Safety & Security and IT Services, will also participate in these reviews, which are coordinated by the FS Project Manager.

The Consultant will formally submit an SD (DD and CD similar) Package with deliverables as described in FS2 for University review. The Project Manger shall facilitate the review process as follows:

Schedule a review orientation meeting with representatives from Facilities Services and University-wide stakeholders as listed below:

- FS - Engineering & Utilities
- FS - Accessibility
- FS - Exterior Environments
- UC – IT Services
- UC – Environmental Health & Safety
- UC – Representative(s) from Risk Management
- Others as required by the project
- FS - Operations
- FS - Sustainability Unit
- UC – User representatives
- UC – Safety & Security

The Consultant shall lead this meeting by providing an overview of the project, the basic building configuration, building systems and infrastructure layout, and walk through the set of SD drawings. Reviewers will be given an opportunity to ask questions and participate in a general discussion. At the conclusion of this initial “Project Orientation” meeting, the FS Project Manager shall summarize the design review process, time frames, and deliverables required.

The Project Manager shall distribute the SD documents (full package) along with review comment logs with instructions to all participants listed above. Documents shall be distributed electronically in pdf format. In addition, full size drawings (24” x 36” or larger) will be provided in hard copies as follows:

- One complete set of full size sets will be located on the 10th floor drafting table
- One complete set of full size sets will be located at the ATS Building
- One record set to be maintained in the project files by the FS Project Manager

Reviewers may request additional sets of hard copies from the Project Manager as needed. The Project Manager shall consider those requests and respond appropriately. All reviewers may contact the Project Manager at any time during the review period with any questions or clarifications required. Reviewers shall return the completed review comment logs to the Project Manager by the required due date. The Project Manager shall be responsible for compiling all review comments and returning those comments to the Consultant for their follow up action.

The Consultant shall address the comments received from the University and complete the comment logs accordingly with action taken. The Consultant shall insert responses to the comments in the comment logs and return the logs to the Project Manager within two weeks of receiving the comments, or as specified by the Project Manager. The comment logs should be included with the review submission for the subsequent phase. If the Consultant’s response is not satisfactory, the Project Manager shall

facilitate the appropriate follow up for the parties to engage in seeking resolution of the issue at hand until a fully satisfactory outcome is achieved. The Consultant shall document all mutually agreed upon resolutions and such documentation shall be incorporated into the comment logs. Upon receipt of the comment logs completed by the Consultant, and assuming that all comments have been satisfactorily addressed, all reviewers shall sign off on that phase using the attached sign off form. The Project Manager shall maintain the sign-off form in the project files.

Review Comment Notes:

1. In general the review period shall be 2 weeks (10 business days). The Project Manager shall adjust this period in conjunction with the project schedule and complexity of the project and the phase. In general, smaller and less complex projects shall require less time and larger and more complex projects shall require more time to enable a thorough and thoughtful review.
2. It is assumed that the Consultant’s documents are in compliance with FS². If there are known deviations from these standards, the Consultant shall highlight these deviations and explain the reasons for such deviations. The University reviewers may consider the Consultant’s explanations and determine whether or not such deviations will be acceptable.
3. The Consultant shall be responsible for maintaining the received review comments in the log as well as sign-off sheets for all phases in the appropriate project filing system. A project cost estimate will typically be submitted as part of the review Package and the estimate will be reviewed against the project budget for reconciliation. The Consultant will be expected to develop alternate cost scenarios to achieve reconciliation if necessary. In some cases, the University will require estimates from both the Consultant and the Contractor or Construction Manager. These estimates are to be reconciled with each other as well.

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

VOLUME II - PROJECT DEVELOPMENT PROCESSES

2. UNIVERSITY DESIGN REVIEWS

The Consultant will make presentations to various groups charged with reviewing and approving the proposed project’s design, typically for projects that include new construction, changes to the University grounds, or modifications to significant public spaces within University buildings. The FS Project Manager will identify those groups requiring review depending on scope of a given project. These groups may include:

- Environmental Health and Safety
- Facilities Services
- Safety and Security
- IT Services
- Accessibility Committee

Additionally, depending on scope and size of project, the following entities may include:

a. FS Design Review

The Facilities Services department leadership may be involved in reviewing and guiding the design process on a project. The review could consist of the FS Project Manager, the CPD Director, Planning & Design Executive Director, and the University Architect.

b. Steering Committee

The Steering Committee member composition is specifically tailored to the project and will include senior FS department personnel along with key user or other University department representatives. The committee will typically meet throughout the project duration to provide guidance on design, budget, schedule and scope objectives. The FS Project Manager will establish these meetings early in the design process and will update the meeting schedule information and prepare meeting agendas as required.

c. Board of Trustees

The University’s Board of Trustees typically meets in March, June, and November to review and approve major projects and issues. Projects of a prominent or large-scale nature are presented to the Board of Trustees for design approval and approval to proceed with construction. Consultant preparation of presentations to the Board of Trustees may be required.

3. UNIVERSITY ADMINISTRATIVE REVIEWS

The Consultant will also make presentations to various groups charged with reviewing and approving other aspects of the proposed project. These groups include faculty, staff, students, and administration:

Accessibility Design Review Committee

This committee meets once a month to review all renovation or new construction projects in regard to accessibility standards. FS will have a representative on this committee who coordinates this committee’s schedule with all projects for accessibility compliance. However, the Consultant will typically make presentations to this committee at the end of each project phase and must accommodate the review within the project schedule. Documentation of, and responses to, committee comments will be provided by the Consultant.

While the review is advisory in nature, it shall be regarded as representing the University’s position on accessibility requirements for the project. The unit responsible for the space may appeal a decision of the Accessibility Design Review Committee by submitting a written request to the Vice-Provost for Academic Affairs. In addition, the Consultant should take note of the University’s accessibility standards which may be more stringent than outside jurisdictions. Requests for exceptions to the University’s accessibility standards may be made to the Accessibility Design Review Committee. The Consultant bears final responsibility for compliance with all applicable laws. Neither any comments offered by the University nor the failure of the University to offer any comments shall in any way reduce the Consultant’s responsibility for compliance with applicable laws.

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

4. EXTERNAL AND REGULATORY REVIEWS

The Consultant is responsible for submitting documents and soliciting review comments at each phase of the process to appropriate outside agencies with jurisdiction on the project. These reviews should be identified on the master project schedule The FS Project Manager must be apprised of the progress and content of all reviews and will convey to the Consultant any sensitivity with regard to government or community discussions and any University protocols and government relationships which exist.

a. Government and Regulatory Agency Reviews

All University construction projects, unless otherwise designated, will require a building permit. The Consultant will be knowledgeable in understanding information requirements, duration of reviews, and other impacts to the project in order to meet the project schedule.

b. Community Reviews

The University has committed to a participatory planning and project implementation process through the Office of Civic Engagement (OCE) to fully engage and collaborate with the aldermanic elected officials and neighboring community that surrounds our urban campus setting.

If required by the nature of the project, meetings with external community entities will be planned under the advisement of the FS Project Manager and OCE at project milestones established at the initiation phase and updated regularly given the scope, scale and complexity of the project. The Consultant will provide the background and technical materials necessary to support these submittals. The Consultant shall attend public hearings related to these submittals as required.

c. Other Resources and Entities

i. PD-43

The University’s core campus is within one of the City of Chicago’s Planned Development zoning districts (PD-43). A zoning review by the Consultant will occur during the project’s initial phase to determine any PD-43 requirements associated with the project.

ii. FM Global

The University maintains property insurance with FM Global. The FS Project Manager will coordinate project reviews and requirements through the University’s Risk Management representative with the Consultant. Typically, any project that results in changes to automatic protection systems, occupancy, water supply or construction (including new construction, additions, and renovations) should be reviewed by FM Global. It is expected that each project meet Factory Mutual Research guidelines, and, as applicable, utilize Factory Mutual Research Approved products.

d. FS Compliance Guide Matrix - See Table 2.01

- i. At each phase of the Design and Construction process, specific deliverables and activities are required to be completed. The purpose of enforcing compliance is to emphasize the importance of certain minimum (FS)² requirements. The University’s FS Project Manager will discuss specific project requirements with Consultants and Contractors as they relate to enforcement provisions. Failure to comply will result in withholding of payment until each deliverable or activity per the (FS)² requirements are satisfactorily completed.

D) CONSTRUCTION DELIVERY METHODS

1. CONSTRUCTION MANAGEMENT

The University frequently engages Construction Management (CM) services in the construction of large or complicated projects on campus. These services typically begin during the Consultant’s design phase work and are meant to complement and assist the Consultant’s efforts in designing to scope, schedule, and budget. The FS Project Manager will coordinate the specific contractual requirements with the Consultant. The CM is typically required to provide a Guaranteed Maximum Price at the completion of the Construction Documents phase.

a. Design/Assist Services

The CM may also be directed to retain Design/Assist Trade Contractor services during design phases. In these circumstances, the Trade Contractors would work collaboratively with the Consultant and CM in the development of more detailed, comprehensive and coordinated project documentation during the preconstruction phase.

2. GENERAL CONTRACTOR

The majority of University projects are bid to General Contractors (GC) based on construction documents prepared by the Consultant.

3. DESIGN BUILD

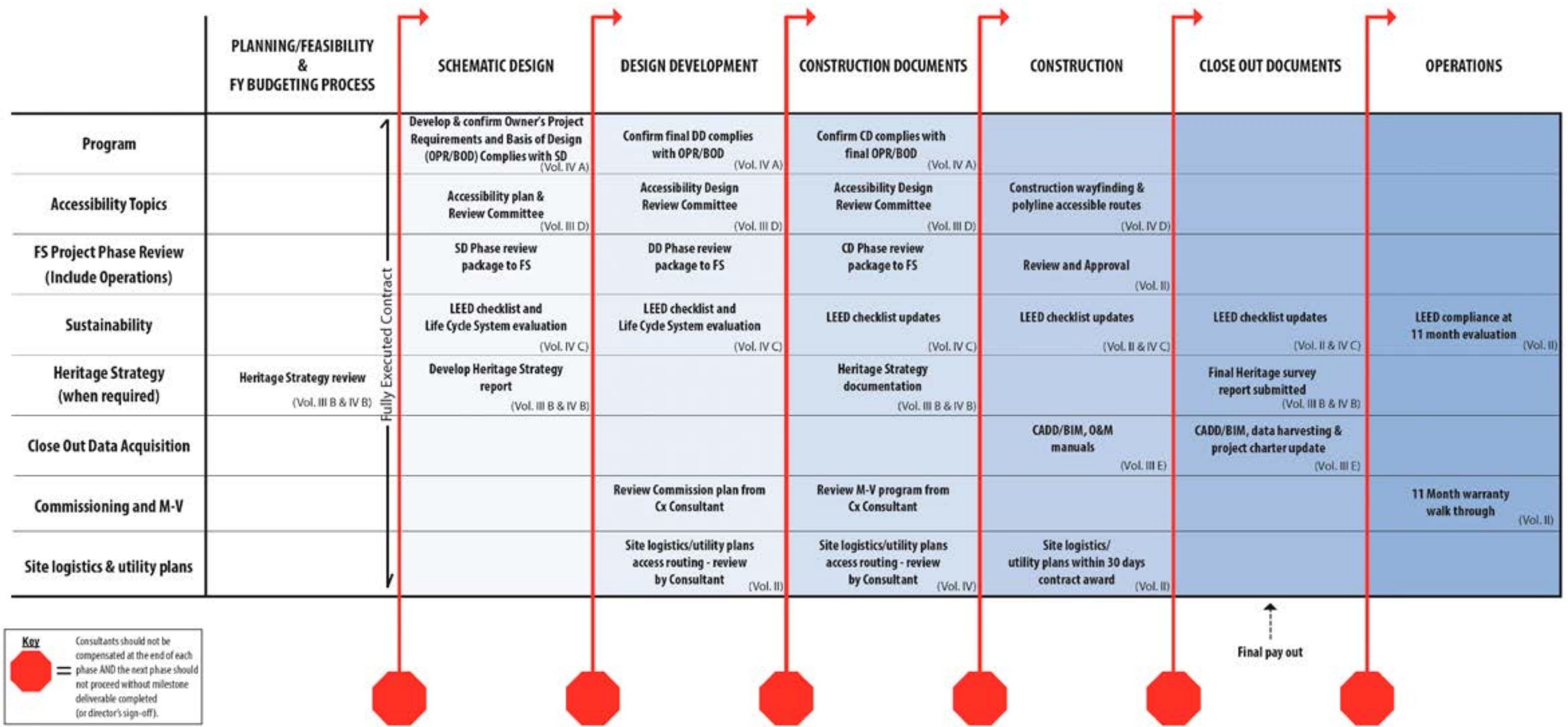
The University will also occasionally negotiate Design-Build services for a project. A determination will be made by the University to pursue such services based on the specific project type, schedule or design parameters.

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

VOLUME II - PROJECT DEVELOPMENT PROCESSES

TABLE 2A.02 - FS COMPLIANCE GUIDE

The deliverables outlined in this project workflow diagram may not identify all project-specific requirements. Please consult with the assigned FS Project Manager and project-specific A/E Agreement and Exhibits for all obligations for each project phase.



The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

A) GENERAL DESIGN AND CONSTRUCTION REQUIREMENTS

1. INTRODUCTION

This portion of the Facility Standards includes general design and construction requirements for use by the Consultant in the course of a project at the University of Chicago.

2. GENERAL DESIGN REQUIREMENTS

a. Owner’s Project Requirements

The Owner’s Project Requirements (OPR) will typically be initiated by the University in the Program Planning or Project Initiation Phase of the project to assist the Consultant in communicating the University’s objectives and criteria for the proposed project. Information about the project is gathered from the users and operators of the proposed facility by the Facilities Services Project Manager or University’s representative. The Consultant will then assist in the development of the OPR document. The OPR document is intended to be modified during the design process as the project’s objectives and criteria are refined. The Consultant will develop the project Basis of Design (BOD) in response to the OPR to show how the design of the project meets the intended goals. In projects requiring LEED certification, the OPR and BOD documents are necessary steps in complying with the commissioning prerequisite. The information contained in the OPR supplements any programming data. Depending on the extent of the programming data, the OPR may also include design goals, performance criteria, budgets, schedules, success criteria, and any additional University directives.

- The following guidelines are to be considered in collecting information for the OPR, along with any specialized project requirements:
- 1. University and User Requirements
 - i. Purpose
 - ii. Program
 - iii. Use
 - iv. Schedule
 - v. Budget
 - vi. Flexibility
 - vii. Future expansion
 - viii. Quality of materials
 - ix. Operating and maintenance costs
 - x. Serviceable life expectancy
 - 2. Environmental and Sustainability Goals
 - i. LEED certification requirements
 - ii. LEED checklist with sustainability priorities
 - 3. Energy Efficiency Goals
 - i. Overall energy efficiency goals relative to local energy code or ASHRAE standards
 - ii. List of energy efficiency measures that provide cost effective energy savings
 - iii. List of other measures (orientation, daylighting, etc.) that impact energy use
 - 4. Indoor and Outdoor Environmental Quality Requirements
 - i. Occupancy schedules
 - ii. Thermal comfort requirements
 - iii. Desired user comfort adjustability
 - iv. Ventilation, exhaust, and filtration requirements
 - v. After-hour usage accommodations
 - vi. Indoor lighting requirements
 - vii. Occupant lighting control requirements
 - viii. Acoustic expectations
 - ix. Health and hygiene requirements
 - x. Accessibility requirements
 - xi. Vibration requirements
 - xii. Adjacent building or space issues
 - xiii. Other requirements (operable windows, views, etc.)

- 5. Equipment and System Expectations
 - i. Building envelope or assembly requirements (humidity control, glazing, etc.)
 - ii. Special HVAC equipment requirements (equipment type, quality, etc.)
 - iii. Special lighting requirements (lamp types different from standards)
 - iv. Special communications, AV, or security requirements
 - v. Serviceability and life expectancy
 - vi. Other system requirements (specific energy targets, desired technologies, etc.)
 - vii. Warranty requirements
- 6. Occupant and O&M Personnel Expectations
 - i. Description of HVAC and lighting system operation and by whom
 - ii. Level of training required for occupants, maintenance, and facilities personnel

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

A) GENERAL DESIGN AND CONSTRUCTION REQUIREMENTS

b. Basis of Design

The project Basis of Design (BOD) will typically be developed by the Consultant in the Programming or Schematic Design Phase of the project in response to the Owner’s Project Requirements (OPR) to show how the design of the project meets the intended goals. The BOD document is intended to be updated throughout the design process as the project’s objectives and criteria are refined. In projects requiring LEED certification, the OPR and BOD documents are necessary steps in complying with the commissioning prerequisite.

The following guidelines are to be used in documenting the BOD deliverables, along with any specialized project requirements:

1. Owner and User Requirements

i. Description of primary design assumptions

ii. Program verification

iii. Schedule

iv. Cost estimate

v. Phasing or expansion description if required

vi. Quality of materials description
2. Environmental and Sustainability Goals

i. LEED credit achievement status

ii. Sustainability priorities achievement status
3. Energy Efficiency Goals

i. Overall energy efficiency intentions relative to local energy code or ASHRAE standards

ii. Life cycle cost analysis

iii. Energy model
4. Indoor and Outdoor Environmental Quality Requirements

i. For major or specific usage areas, design assumptions or criteria for applicable requirements:

· Occupancy schedules

· Thermal comfort requirements

· Desired user comfort adjustability

· Ventilation, exhaust, and filtration requirements

· After-hour usage accommodations

· Indoor lighting requirements

· Occupant lighting control requirements

· Acoustic expectations

· Health and hygiene requirements

· Accessibility requirements

· Vibration expectations

· Adjacent building or space safeguards

ii. Other design assumptions, such as diversity factors
5. Equipment and System Expectations

i. For major or specific usage areas, description of:

· Building envelope or assemblies

· HVAC systems and equipment

· Lighting systems and equipment

· Special communications, AV, or security systems

· Serviceability and life expectancy

ii. System selection rationale for each system

iii. Design criteria for each system

iv. Sequence of operation if applicable

v. Warranty expectations if applicable

6. Occupant and O&M Personnel Expectations

i. Description of HVAC and lighting system operation and by whom

ii. Level of training required for occupants, maintenance, and facilities personnel.

B) STEWARDSHIP AND HERITAGE RESOURCES

1. INTRODUCTION

Founded in 1890, the University of Chicago has a rich history of intellectual innovation and has been connected to numerous Nobel laureates and other prominent figures. In addition, the University’s campus buildings and grounds display the work of many world-renowned architects and builders.

Four different regulatory designations – Chicago Landmark, Chicago Historic Resources Survey, National Register of Historic Places, and National Historic Landmark – serve to identify, evaluate, and protect architectural and historic resources. The Chicago Department of Planning and Development (DPD) reviews all permits for work involving designated and proposed Chicago landmarks and landmark districts. Through the Planned Development zoning designations that encompass the University, DPD conducts additional reviews related to heritage resources especially as to certain properties identified in the Chicago Historic Resources Survey.

Planned Development (PD) 43 is the zoning designation that encompasses the contiguous campus of the University of Chicago and UChicago Medicine. It encourages unified planning and development that is compatible with the character of the campus and surrounding neighborhoods. The document governs land use, building and landscape design, and traffic management. The University campus is subdivided into twelve subareas, which further specify permitted use and building height. Subarea O has specific requirements for heritage structures identified by the Chicago Historic Resources Survey.

In addition to PD43, several other facilities associated with the University of Chicago are designated as Planned Developments. These include PD215 (Earl Shapiro Hall on S. Stony Island), PD1216 (Facilities Services Building on S. Cottage Grove), and PD1287 (Woodlawn Charter School).

2. HERITAGE INFORMATION

Various external and internal sources of information provide guidance regarding existing heritage requirements.

a. External Regulatory Information

Four different designations serve to identify, evaluate, and protect architectural and historic resources:

- 1. Chicago Landmark: a designation by the City Council of sites, objects, or entire districts of architectural and historical significance, thereby providing legal protection.
- 2. Chicago Historic Resources Survey (CHRS): completed in 1995, was a decade-long research effort by the City of Chicago to analyze the historic and architectural importance of all buildings, objects, structures, and sites constructed in the city prior to 1940.
- 3. National Register of Historic Places: Authorized by the National Historic Preservation Act of 1966, part of a national program to coordinate and support public and private efforts to identify, evaluate, and protect America's historic and archaeological resources.
- 4. National Historic Landmark: a building, district, object, site, or structure that is officially recognized by the United States government for its outstanding historical significance.

b. Internal Heritage Information

Campus Planning + Sustainability within Facilities Services collects internally developed heritage reports for specific buildings and grounds locations. These reports include historical context, general architectural descriptions, drawings, photographs, and bibliographies.

3. PROJECT REQUIREMENTS & REFERENCES

In doing design work on campus, the consultant should work with the project manager to see what heritage information needs to be collected. If there is insufficient heritage information, Campus Planning + Sustainability should be engaged to identify what is needed. In some cases, a project may require a new heritage report or development of urban design guidelines.

See [Guidance for Design Teams](#) for additional information.



C) SUSTAINABILITY

1. INTRODUCTION

This portion of the Facility Standards includes sustainability guidelines to be followed by the Consultant in the course of a project at the University of Chicago.

Conventional construction and operation of buildings are resource-intensive processes that create a significant amount of waste and contribute to global climate change. The environmental impact of a building is significant, and has implications for the local community and the world beyond our borders. Locally, the University faces environmental and political concerns such as water use and quality, land use, energy consumption, and ongoing operations and maintenance costs. The entire range of impacts should be taken into consideration when designing and constructing buildings.

These guidelines complement the implementation of the University of Chicago’s Strategic Sustainability Plan, specifically High Performance Buildings. They will help the University place clear parameters and identify measurable results around what it means to be truly sustainable. The goal is to incorporate principles, materials, and actions into building design, construction and maintenance.

2. SUSTAINABILITY PROCESS

Each Process Phase is presented below and discusses specific process activities as they pertain to sustainability. The greatest achievement in sustainability occur by maximizing both the environmental and economic return on investments through design, construction and maintenance standards to improve resource conservation and create healthy spaces in a way that’s meaningful for the people who study, teach or live in our buildings. Decisions made in one area often affect many other areas.

The guidelines outline an integrated design approach. Each step is identified to establish performance goals and to ensure that decisions are made in a collaborative and informed manner. The maximum benefit for minimum cost are achieved when sustainability is incorporated at project inception.

Table 3C.01 Processes by the University prior to Consultant engagement

Process Phase	Accessibility Objective
Program Planning/ Project Initiation	Translate academic or departmental initiatives into potential facility needs to determine if a capital construction project is necessary. As part of that effort, a mandatory meeting attended by the FS Project Manager, Office of Sustainability and key stakeholders must be held to discuss potential sustainable approaches.
	Incorporate the sustainability issues discussed previously into the Request for Proposal (RFP) and Owners Project Requirements (OPR) outlined in the Standards. Understand anticipated costs or savings that may be incurred in order to create a more sustainable building.
Programming	During the Programming phase, the OPR should be further developed to incorporate sustainability goals as they pertain to user needs and design parameters. As the project team develops or verifies the project program, summary schedule, and preliminary budget, the FS Project Manager should arrange a sustainability workshop to review the options and the underlying principles of sustainability as they relate to building design, construction and operation. A sustainability coordinator is to be designated during this meeting.
	Consultant is to begin development of the Basis of Design (BOD) and sustainability checklist (LEED, Living Building Challenge or other, as agreed upon by stakeholders) in response to the OPR and results of the sustainability workshop.
Schematic Design	At the beginning of the Schematic Design (SD) phase, program priorities and associated assumptions should be reevaluated to determine if spaces and functions can be shared or co-located with the sustainability goal of reducing the volume of the building, increasing space efficiency, using fewer raw materials and optimizing energy and water use.
	The largest energy impacts should be identified, prioritized and discussed at design meetings. Energy modeling should be used to evaluate energy efficient design alternatives and refine the project’s sustainability goals and energy usage. The results are to be incorporated into the BOD document and sustainability checklist.
Design Development	During the Design Development (DD) phase, the approved schematic design begins to include a level of detail necessary to work out a clear, coordinated description of all aspects of the project. Because the DD phase is one of the last opportunities for the User Group to become involved in the design, it is crucial that sustainability principles from each of this document’s categories be fully discussed and implications be understood and integrated as appropriate.
	Design and construction costs associated with the sustainable elements of the project should be clarified. Sustainable component cost metrics (capital and life cycle) should be developed and cost and/or savings decisions evaluated against performance and life cycle cost considerations. The results are to be refined within the BOD document and sustainability checklist.
	The project team should ensure that the project schedule allows adequate time for implementing the activities that may lead to a more sustainable project such as commissioning, life cycle analysis and training, among others.
Construction Documents	During the Construction Document (CD) phase, a comprehensive, fully coordinated set of construction documents and specifications are issued to obtain the necessary permits and construct the project. A review of sustainability elements by appropriate Facilities Services and project team stakeholders must be included in the 50% CD review along with any update of the BOD document and sustainability checklist. This review should specifically address materials selection.
Construction	At the start of the Construction phase, a representative from the general contractor, each subcontractor and a designated sustainability coordinator should attend the pre-construction meeting. The sustainability goals and design features of the project should be made clear at this meeting. Review of the project sustainability requirements should occur if applicable. Contractor ideas and opinions should be encouraged during these discussions to allow for innovations and efficiencies.
Closeout	Closeout facilitates the occupancy and turnover of the finished and fully commissioned project to the user group and maintenance department. It is important for building occupants and maintenance personnel to understand how their facility is designed to function, particularly as it relates to specific user behavior, in order for it to operate as designed. The designated sustainability coordinator is to facilitate contributions from all project team members towards the development of a training program to educate personnel about the relevant features of the building and how they are meant to operate, including any user-influenced control strategies.

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

C) SUSTAINABILITY

3. GUIDELINES

These guidelines are for use by Facilities Services personnel and Consultants on projects of all scales. Although the University’s current Sustainable Building Policy requires implementation of minimum LEED Silver certification standard for larger projects (new buildings over \$5 million in total project costs), all projects are to follow these guidelines.

The guidelines are organized into the following categories:

- a. SUSTAINABLE SITES
- b. WATER EFFICIENCY – WISE WATER GUIDELINES
- c. ENERGY
- d. MATERIALS & RESOURCES
- e. HEALTH, COMFORT AND PRODUCTIVITY
- f. EDUCATION AND TRAINING
- g. INNOVATION

The discussion of each category begins with a set of goals, followed by a list of suggested strategies to be used in achieving those goals. The strategies included are not comprehensive; they are intended to provide ideas, and not exclude any from consideration. The project team should develop additional strategies. The following are suggested reference documents: latest version of the LEED Reference Guide, Living Building Challenge Rating System or the Sustainable Site Initiative Guidelines, among others. Contact the Office of Sustainability for a more extensive list.

WHOLE BUILDING DESIGN APPROACH

Application of a whole-systems design approach is crucial for sustainability. Categories and strategies are interdependent; none stand in isolation. Decisions made in one area may affect the performance in another. For example, careful decisions on building shape and window placement that take into account both prevailing wind and sun angles may not only enhance a building’s thermal performance but can also improve daylighting. On the other hand, considering one building system alone without regard to others may result in poorer performance in the other systems. Any conflicts among categories should be resolved using an integrated design approach; and careful decisions should be made to select those designs that can trigger multiple savings or other benefits. It is essential that all members of the project team work together and consider all sustainability categories in order to be aware of the influence of their decisions on the overall performance of the building. In addition, not all strategies suggested here are relevant for every project. Considerations and decisions will have to be balanced by the Project Team and strategies that make sense will need to be negotiated.

C) SUSTAINABILITY

a. SUSTAINABLE SITES

Goals:

- Promote sensitive development that relates well to natural systems and existing infrastructure.
- Maintain and enhance the biodiversity of natural systems and/or existing character of the site.
- Respond to campus microclimates and natural site conditions.
- Reduce energy use for transportation and site related activities.
- Contribute to the cohesiveness and intelligibility of the existing campus.

Strategies:

Guide Development to Environmentally Appropriate Infill Areas.

As much as possible, select a site that:

- Is characterized as previously developed land.
- Utilizes a floor-area ratio that is at minimum in the range of 0.25 - 0.35 (or equivalent).
- Avoids habitat for any sensitive species.
- Avoids the loss of mature trees.

Maintain and Enhance the Biodiversity and Ecology of the Site

Integrate the building with the site in a manner that minimizes the impact on natural resources, while maximizing human comfort and social connections. The development footprint should enhance the existing biodiversity and ecology of the site by strengthening the existing natural site patterns and making connections to the surrounding context. Apply appropriate strategies below:

- Minimize the impacts of the development process to reduce ecological disturbance.
- Design the site to reconnect fragmented landscapes and establish contiguous networks with other natural systems both within the site and adjacent systems beyond its boundaries.
- Minimize the area of the site dedicated to the building, parking, and access roads and attempt to increase the floor-area ratio beyond the campus average.
- Site the building to create traffic patterns that promote non-motorized access.
- Maintain setbacks that effectively utilize the site while respecting surrounding environments.

Optimize Building Placement and Configuration

Place, orient, and configure the building on the site to:

- Optimize daylighting.
- Reduce heat island effects.
 - Minimize non-permeable surfaces.
 - Optimize stormwater management via onsite retention or reuse
 - Maximize alternative transportation options.

Use Microclimate and Environmentally Responsive

Site Design Strategies

Design the site and building to respond to microclimate and environmental conditions. Consider and apply the appropriate strategies below:

- Locate trees and shrubs to support passive heating and to complement cooling in outdoor spaces and buildings and to create seasonal heat-sinks and natural ventilation corridors.
- Locate site features (plazas, patios to take advantage of seasonal sun angles and orientation.
- Design the overall site to reduce “heat island” effects. Exploit shading opportunities, and explore the possible use of high albedo materials. Consider pervious surfaces for parking, walkways, plazas, etc. Use permeable paving for roads with infrequent use.

C) SUSTAINABILITY

b. WATER EFFICIENCIES

Goals of Wise Water-Use Guidelines:

- Increase the harvesting and recycling of water resources in building and landscape projects
- Reduce the consumption of potable water
- Maintain the aesthetics of the campus landscape and botanic garden
- Minimize impacts to natural resources from the discharge of storm water
- Encourage prudent financial decisions associated with water use
- Calculate life cycle costs of alternative system for payback of investment

Strategies:

Erosion Control

- Prevent soil erosion before, during, and after construction by controlling stormwater runoff and wind erosion. Consider silt fencing, sediment traps, ditch checks, construction phasing, stabilization of slopes, and maintaining and enhancing vegetation and groundcover.

Reduce Site Water Consumption

Minimize the need for irrigation.

Consider and apply the appropriate strategies below:

- Select drought tolerant plant species, permeable materials, bioswales or other low-tech solutions as a primary option.
- When irrigation is needed, use efficient systems, including drip irrigation, efficient nozzles, moisture sensors, and weather data-based controllers.

Reduce Building Water Consumption

Design strategies and systems to reduce building water use to exceed the current requirements of US EPA Water Sense. Consider and apply the appropriate strategies below:

- Use infrared faucet sensors, delayed action shut-off or automatic mechanical shut-off valves.
- Use low flow or dual flush toilets that have been tested and rated to function reliably that use a maximum of 1.28 gallons per flush (GPF)
- Use 0.125 or 0.5 GPF urinals.
- Use lavatory faucets with flow restrictors for a maximum rate of 0.5 gallons per minute (GPM), or use metering faucets at 0.25 gallons per cycle.
- Use low-flow showerheads with preferably 1.5 GPM or a maximum of 2.0 GPM
- Use equipment that meet EPA ENERGY STAR® requirements where applicable.

C) SUSTAINABILITY

c. ENERGY

Goals:

- Maximize energy performance of infrastructure and building systems to reduce total consumption and peak energy demand. Pursue renewable energy as a lower priority.
- Reduce greenhouse gas emissions, pollution and climate change caused by energy production.
- Reduce ongoing operations costs associated with utility consumption
- Improve indoor air quality through a holistic mechanical design approach, in which it is designed relative to other design goals such as energy use, carbon footprint, comfort, etc.

Strategies:

Set Energy Use Intensity Targets Prior to Conceptual Design

On appropriate large-scale projects, set energy use intensity (EUI) targets, as a requirement the design and construction team must commit during the team selection process. Potential targets must be carefully studied and set, typically via a third-party consultant hired by Facilities Services. The design team must substantiate claimed energy performance via an energy model review process and actual measurement during a defined period of time after substantial completion.

Optimize Building Envelope Thermal Performance

Design building envelope to optimize thermal performance.

Consider and apply the following:

- Size openings, select glazing, and utilize shading devices (interior or exterior) to optimize daylighting and glare control while minimizing unwanted heat loss and heat gain.
- Optimize insulation to reduce heating and cooling energy consumption by heat losses and gains through the building envelope.
- Moderate interior temperature extremes by using thermal mass where appropriate.

Provide Daylighting Integrated with Electric Lighting Controls

Ensure that daylighting is designed in coordination with the electric lighting system to reduce energy consumption while maintaining desired lighting characteristics.

Consider and apply the appropriate strategies below:

- Shape the architectural plan and section and use appropriate strategies to maximize the amount of useful daylight (e.g., roof monitors, clerestory windows, atriums and courtyards).
- Use shading devices such as overhangs on south elevations, vertical fins on east and west elevations, and/or vegetation to let in natural light but reduce glare and overheating.
- Use light shelves combined with higher, more reflective ceilings to bring natural light deeper into perimeter spaces and control glare and excessive contrast.
- Use photocell-dimming sensors that adjust electric lighting in response to available daylight.

Provide Efficient Electric Lighting Systems and Controls

Design the lighting systems and components to minimize artificial lighting energy use while still meeting high visual quality.

Consider and apply the appropriate strategies below:

- Use fluorescent or LED lamps and luminaires with electronic ballasts.
- Use controls to reduce energy use (e.g., dimmers, occupancy sensors, photocells, time clocks).
- Use low levels of ambient light augmented appropriately by task lighting.

C) SUSTAINABILITY

Maximize Mechanical System Performance

Design the building heating, ventilating, and air conditioning (HVAC) system to minimize energy use while maintaining standards for indoor air quality and occupant comfort. Consider and apply the appropriate strategies below:

- Use central chilled water system when building in the core campus.
- Use life cycle analysis to determine if central campus steam (less efficient) or building systems (more efficient), such as stand-alone boilers, are appropriate as the building heating source
- Group similar building functions into the same HVAC control zone so those areas can be scheduled separately (e.g. separate around-the-clock areas from classrooms and offices).
- Apply direct/indirect evaporative cooling and/or pre-cooling for conditioned spaces.
- When not using central steam or chilled water, design boilers and chillers using high efficiency equipment, use multiple modular boilers to allow more efficient part-load operation, high efficiency condensing boilers, or gas heater/ chillers.
- Modulate outside air according to occupancy, activities, and operations. Use occupancy sensors and variable air volume distribution systems to minimize unnecessary conditioning.
- Install occupancy control and automation programming/ control sequences that enable pandemic mode settings for mechanical system operations. These controls will also facilitate MBCx.
- Use heat recovery systems to reduce heating energy use.
- Use zero CFC-based refrigerants in HVAC and efrigeration equipment. Phase out CFC-based refrigerants for renovation projects.

- Design systems to accommodate MERV 8 prefilters and MERV 13 filters with space to accommodate future installation of air sanitization systems like BPI or UV where practical.

Use Efficient Equipment and Appliances

Design and/or select any building equipment and appliances to optimize energy efficiency.

Consider and apply the appropriate strategies below:

- Use equipment with premium efficiency motors and variable speed drives.
- Select EnergyStar equipment (including transformers) and appliances
<https://www.energystar.gov/productfinder/>
- Use efficient equipment to heat and supply service water to the building. When feasible, consider use of tankless water heaters.

Use Energy Sources with a Low Environmental Impact

Consider alternative sources and supply systems to reduce the building’s source energy load and minimize green house gas emissions. Consider the building or central campus utility scales.

- Evaluate the feasibility of on-site renewable energy
- Evaluate possibilities for alternative building specific energy supply systems (such as fuel cells).
- Consider energy providers with a higher percentage of renewable energy in its generation mix.
- Investigate financial rebates or incentives offered by the City of Chicago, Com-Ed, or others.

C) SUSTAINABILITY

d. MATERIALS & RESOURCES GOALS:

- Reduce consumption and depletion of material resources, especially nonrenewable resources.
- Minimize the life-cycle impact of materials on the environment.
- Enhance indoor environmental quality.
- Minimize waste generated from construction, renovation, and demolition of buildings.
- Encourage better management of and minimize waste generated during ongoing occupancy.

Strategies:

Use Materials with Low Life-Cycle Cost

Use a life-cycle methodology to evaluate materials. Choose materials, especially those used in large quantities, with the lowest environmental impact when possible.

Production

In order to conserve embodied energy, which is the total amount of energy needed to create a material from raw extraction to finished life of the product, and reduce the consumption of natural resources, consider the following:

- Salvaged materials (eg reuse furniture, other building materials).
- Remanufactured materials, such as engineered wood products.
- Recycled-content products and materials (post-consumer is preferred over pre-consumer).
- Reusable, recyclable, and biodegradable materials.
- Materials from rapidly renewable sources (e.g., wheat, cotton, cork, bamboo, etc.).
- Wood certified by the Forest Stewardship Council.

Use Locally Manufactured Materials

Obtain materials and products from local sources and manufacturers (within 250 miles of project site), minimizing energy use and pollution associated with transporting from great distances.

Use Durable Materials

Use products or materials (including masonry, steel, glass, and timber products such as beams, columns, floorboards, etc.) that are durable (with a life cycle of at least 50 years), weather well, and last more than one building lifetime (i.e., through a reuse or remodel).

Design for Less Material Use

- Adapt and reuse existing buildings as a primary option.
- Employ design strategies to use fewer materials, including reducing the size of the building or spaces; eliminating unnecessary architectural, finish materials; using modular and standard dimensioning; and using strategies that decrease construction waste.

Design Building for Adaptability

Incorporate interior or exterior design options into the project to facilitate building adaptability.

Consider and apply the appropriate strategies below:

- Consider site planning and building configuration for future additions and alterations.
- Plan for maximum standardization or repetition of building elements and details to increase the ease of adapting the structure for future alterations or upgrades.
- Design cladding to accommodate future alterations and upgrades such as shading devices, more efficient glazing, and lighting controls.
- Use materials, systems, and components that can be disassembled for reuse or recycling.

- Use raised floor systems where appropriate for power and telecommunications wiring to accommodate reconfiguration of spaces and information technology support.
- Use modular space planning, partitions, and furnishings.

Design Building for Disassembly

Incorporate interior or exterior design options into the project to facilitate building disassembly.

Consider and apply the appropriate strategies below:

- Use structural systems, cladding systems, and wall systems that facilitate disassembly.
- Use structure/shell systems that maintain integrity when demounted or disassembled (e. g., steel, glass, or concrete and panel claddings).
- Use materials, systems, and components that can be disassembled for reuse or recycling.
- Use snap release connectors, friction, or other joints which do not require sealants. Use joints and connections that facilitate disassembly, including bolts, screws, and clips.
- Use homogeneous materials rather than composite materials (such as reinforced plastics and carpets fibers and backing), as they are generally easier to separate and recycle.
(An exception is the use of engineered wood products, which are composites)

C) SUSTAINABILITY

e. HEALTH, COMFORT AND PRODUCTIVITY GOALS:

- Provide, monitor and maintain high indoor air quality during demolition, construction and ongoing building operations.
- Provide occupants with operational control of lighting and HVAC systems where practical.
- Produce environments that enhance human comfort, well-being, performance, and productivity by providing healthy spaces.
- Connect building occupants physically or visually to nature

Strategies:

Provide Healthy Ventilation

- Comply with regulations, such as ASHRAE 62.1, that pertain to the design, operation, inspection and maintenance of ventilation systems
- Design mechanical systems to accommodate additional fresh air (up to 30%) and modulate accordingly. Consider DOAS with heat recovery.
- Provide occupants access to operable windows
- Specify materials that control moisture and discourage microbial growth.
- Address moisture control on the site, within the building envelope and inside the building.
- Use appropriate HVAC filters, entry vestibules, floor mats and other appropriate strategies to control dust and pollutants
- Conduct a building flush-out of 14,000 cubic feet of outside air per square foot that follows LEED guidance, where possible.

Use Low Volatile Organic Compounds-emitting Materials

Use LEED compliant low or no Volatile Organic Compound (VOC)-emitting materials (including paints, coatings, adhesives, carpet, ceiling tiles, and furniture systems) to help ensure good indoor air quality.

- Comply with Facilities Standards that focus on the selection and management of new construction materials and renovation activities in order to minimize indoor air quality issues.
- Ensure that all construction materials, interior finishes, and major furnishings installed at the University comply with the most recent LEED standard for VOC content and Emissions Evaluation, including interior paints and coatings applied on site, interior adhesives and sealants applied on site, flooring, composite wood, ceilings, walls, thermal and acoustic insulation, and furniture.
- Follow material conditioning procedures.
- Follow sequencing procedures (e.g., let wet products dry before installing porous products).
- Reduce dust emissions in occupied buildings through the use of wet methods, etc.
- Submit data for review and approval prior to construction for projects that require:
 - a. The use of potentially toxic or odor producing products (e.g., roofing, paint, epoxy)
 - b. Projects conducted in close proximity to sensitive areas.

Provide Appropriate Thermal Comfort

- Use operative temperature to address environmental and seasonal considerations for dry bulb and radiant temperature profile, relative humidity and occupants’ activities and modes of dress.
- Provide occupants controllability over workspace temperature controls, operable windows and operable window shading devices

Provide Effective Lighting

Illuminance Levels: Use design strategies and features to ensure that the Illuminance Levels and Luminance Ratios comply with these Standards and are appropriate for the users and tasks.

- Color Temperature: Use design strategies and features to ensure that color temperature, color rendering, and modeling of light are appropriate for the users, activities and tasks.
- Glare: Use design strategies and features (e.g., selection of lighting fixtures, installations, and controls) to avoid glare in ways that support the program, user purposes, and preferences.

Connect Interior Spaces Physically or Visually to Nature

- Provide connection to the outside via doors, operable windows or views in workspaces
- Include natural elements on the interior, such as daylight, water, vegetation, natural ventilation
- Provide indirect connection to nature via natural patterns or other concepts of biophilic design

Provide Appropriate Building Acoustical and Vibration Conditions

- Vibrations: Use strategies to control sources of external and internal vibrations.
- Noise Control: Use design features and strategies to control sources of noise from mechanical and electrical equipment and from sources exterior to the building. Select wall assemblies with appropriate Sound Transmission Class (STC) ratings based on the conditions of the site, building program and activities. Noise elimination, control, or isolation from equipment should be addressed through acoustic zoning, equipment selection, construction, and appropriately designed ducts, piping, and electrical systems.
- Soundscapes: Use design features and strategies to create appropriate sound reverberation levels, background sound levels, sound rendition, and speech interference levels.

C) SUSTAINABILITY

f. EDUCATION AND TRAINING

Goals:

- Buildings foster experiential sustainable education through interactive features and design
- Allow occupants to monitor and understand their daily environmental footprint
- Provide occupants strategies to reduce their consumption of resources
- Through training, ensure staff have adequate knowledge of optimum sustainable operations

Strategies:

Physical Infrastructure Enables Education

- Interactive signals tied to building systems cue occupants on energy saving behavior, such as opening windows or closing shades
- Building Automation System (BAS) collects energy and water usage, real-time. A building specific webpage displays this information.
- Utility sub-metering facilitates detailed energy monitoring and allows energy saving competitions and games with results displayed real-time
- Consider the installation of RESET Accredited continuous air quality monitors
- Graphic signage details sustainable practices, building features and optimum behaviors
- Project teams are encouraged to seek unique innovation opportunities beyond the ‘typical dashboard in the lobby’, such as interactive art, tactile natural materials, etc.

Training and Engagement Programs

- Project team creates a building specific manual that addresses best practices for students, faculty, staff, visitors, building operators and any other appropriate user groups.
- Via discussion with project stakeholders and communications staff, create an action plan identifying optimum methods to disseminate the best practices defined in the building manual
- Hold educational workshops for building user groups near move-in that clearly define best practices and expectations for sustainably inhabiting the facility
- Create an orientation process for new building users that defines sustainable expectations

g. INNOVATION

Innovation in Design and Regional Priority

Project teams are encouraged to use every opportunity to achieve exceptional building performance and incorporate new and innovative sustainable strategies, particularly those that are regional.

C) SUSTAINABILITY

4. LIFE CYCLE COST ANALYSIS

Life Cycle Cost Analysis (LCCA) is used to evaluate the economic performance of a building over its entire life by balancing the initial investment with long-term expense of operation. In order to best understand the implications of a given project, each design alternative is tested using LCCA. Total cost of ownership, from initial construction cost to operations and maintenance is analyzed and the best solution selected based on a holistic understanding gained from LCCA. These LCCA guidelines are meant to help project teams calculate these costs and inform design and construction decisions.

LCCA will be implemented within each project phase. An explanation of how LCCA is to be used is identified in the Process Phase section of this document. Major LCCA activities that are incorporated into the process include Operations & Maintenance Cost Benchmarking and Comparative Analysis.

a. Study Categories

The project team will assess the value of up to 14 possible life cycle cost (LCC) comparisons in six general categories: Energy Systems, Mechanical Systems, Electrical Systems, Building Envelope, Siting/Massing and Structural Systems. The 14 comparison areas follow, with examples of options that might be considered in each. These examples are only a starting point; specific systems or options considered will vary with the type, scale and intended use of the building.

Energy Systems:

- 1. Central plant-connected vs. stand-alone systems (steam & chilled water)
- 2. Alternative energy systems (e.g., solar photovoltaics, solar thermal, geothermal)
- 3. Equipment Options for stand-alone systems (e.g., air cooled chillers vs. direct expansion units)

Mechanical Systems:

- 4. Air distributed systems (e.g., variable volume vs. constant volume, overhead vs. underfloor)
- 5. Water distribution systems (e.g., various piping systems and pumping options)

Electrical Systems:

- 6. Indoor lighting sources and controls
- 7. Outdoor lighting sources and controls
- 8. Distribution (e.g., transformers, buss ducts, cable trays)

Building Envelope:

- 9. Skin and insulation options
- 10. Roofing systems (various materials and insulation methods)
- 11. Glazing, daylighting and shading options

Siting and Massing:

- 12. Orientation, floor to floor height and overall building height
- 13. Landscape, irrigation and hardscape options

Structural Systems:

- 14. Systems/materials selection (e.g., wood vs. steel vs. concrete, cast in place vs. pre-cast)

Study Selections

The project team will determine which studies have the highest potential LCC benefit for the project. An LCCA Decision Matrix can assist in this determination. The team should create a customized matrix, using the example below. The Yaxis represents the potential cost impact. The X axis reflects the complexity of the analysis required.

When the six categories and/or 14 analyses are compared on such a matrix, they become easier to prioritize. Those in Quadrant I (simple analyses with high potential cost impact) should have the highest priority. Studies requiring complex analyses but have a high potential impact should be prioritized next (Quadrant II). Simple analyses with low potential impact are next (Quadrant III), followed by complex analyses with low potential impact (Quadrant VI). By taking time to prioritize LCC analyses, the Project Team can focus on those studies most appropriate for the project.

Conducting Comparative Analysis

Each comparative analysis is developed on a project specific basis. The FS Project Manager and Consultant groups will decide together how to determine the details of each analysis. A “base case” will be established. The project team will then draw upon its collective experience to identify alternatives to the base case.

Technical guidelines within this section discuss the format used to record the results of the comparative analyses. While this format is intentionally generic (to accommodate various types of studies), all FS Project Managers must use the same format so that the data collected and analyzed are documented consistently. The results of each team’s studies will be incorporated into an LCCA library for future reference so the University can establish a database of studies as both a reference for future projects.

Selecting Cost-Effective Alternatives

The guidelines for LCCA give project teams the direction and tools to use LCCA to inform project decisions. The team should use LCCA incremental cost and payback findings in concert with other factors such as sustainability and user preferences to determine the final project design elements.

Alternatives that result in a payback of 5 years or less are required to be incorporated into the project. Alternatives that result in a payback of 6 to 10 years are strongly encouraged. Alternatives resulting in paybacks over 10 years are discretionary.

Documentation and supporting explanations should be included to document considerations.

C) SUSTAINABILITY

b. LCCA Process

Operations & Maintenance Cost Benchmarking

During the Program Planning and Project Initiation phases of the project, the FS Project Manager will have developed a “Benchmark Budget” with design and construction cost estimates based upon data from past projects. The Facilities Services O & M group will have also developed O & M benchmarks using historical operations and maintenance data from existing campus buildings for those LCCA components that apply to the project.

Comparative Analysis

During the Programming, Schematic Design and Design Development phases of the project, the project team makes increasingly detailed decisions about the final design for the building, including mechanical, electrical, structural, telecommunications and plumbing systems. During this period, the FS Project Manager will direct the team to conduct a series of analyses comparing the total costs of various building system options. Definitions of LCCA steps to follow when conducting analyses are described below and provide constants (energy and discount rates, etc.) to be used.

Table 3C.02 LCCA Process Phase Summary

Process Phase	LCCA Objective	Leader
Program Planning/ Project Initiation	• Assign O & M benchmark	FS Project Manager/ FS O&M
Programming	• Develop O & M cost benchmark in addition to project benchmark • Hold LCCA work session, in conjunction with the Sustainability Charrette • Develop LCCA Decision Matrix	FS Project Manager
Schematic Design (SD)	• Review LCCA Decision Matrix • Determine which LCCA studies to perform • Select cost-effective alternates per LCCA studies • Report results of LCCA	FS Project Manager
Design Development (DD)	• Review LCCA studies to confirm/verify results given project development	FS Project Manager
Construction Documents (CD)/Permitting	• Confirm value engineering decisions from earlier design phases with LCCA results	FS Project Manager
Construction	• Outline LCCA elements to contractor • Discuss commissioning and testing requirements	FS Project Manager
Closeout	• Conduct training program; perform ten-month evaluation	FS Project Manager
Operational	• Validate LCCA study outcomes and assumptions	FS O & M

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

C) SUSTAINABILITY

Program Planning/Project Initiation
(Prior to Consultant Engagement)

The goal of Program Planning is to translate academic or departmental initiatives into potential facility needs to determine if a capital construction project is necessary. The LCCA goal during this phase will be to assign an O&M Benchmark for the long-term costs of the building.

Programming (Subsequent to Consultant Engagement)

The overall goal during the Programming phase is to further develop the options outlined through Program Planning and approve one option for further consideration. The LCCA goal will be to reconfirm the O&M Benchmark. As part of the process, the FS Project Manager should update the O&M Benchmark and arrange an LCCA work session to review the Guidelines for LCCA.

Schematic Design

Schematic Design (SD) is a critical phase of project development during which the general scope, initial design, scale and relationships among the components of the project are determined and the greatest level of LCCA effort will take place. The project team will select the comparative analyses to be performed, assess the results and determine which design elements would generate long-term cost savings. The results of the LCCA studies will be reported as a part of the SD submittal, which will clearly state LCCA elements that have (or have not) been incorporated into the project design. The LCCA results will document incremental University investments in building design elements with long-term benefits for the institution. LCCA results will also note elements that would have not been incorporated into the project due to budget constraints. These results will allow the University to reassess the project budget and scope, based on the potential to realize greater returns over time. The FS Project Manager will consider schedule and budget impacts of the LCCA options studied.

Table 3C.03 Program Planning/Project Initiation (Prior to Consultant Engagement)

LCCA Tasks	LCCA Deliverables
As Part of the Capital Planning process, O & M costs are estimated	None at this stage

Table 3C.04 Programming (Subsequent to Consultant Engagement)

LCCA Tasks	LCCA Deliverables
- FS Project Manager and project team verify the O&M Benchmark - FS Project Manager and project team will create a project-specific LCCA Decision Matrix to determine which LCCA studies benefit the project most. - FS Project Manager documents cost and scheduling implications of LCCA studies.	- Documentation of assumptions for the O&M Benchmark (e.g., if based on historical performance of similar buildings, list of buildings and their O&M costs). - Complete project-specific Decision Matrix - Completed project schedule and budget, with breakdown of LCCA elements.

Table 3C.05 Schematic Design

LCCA Tasks	LCCA Deliverables
- Review the LCCA Decision Matrix and identify studies - Perform LCCA studies in conformance with the technical guidelines listed in chapter 4.3. - Assess studies and select LCCA elements to be incorporated. - Document LCCA results, budget and schedule implications.	- Final LCCA Decision Matrix with selected studies highlighted. - Completed LCCA comparative studies - Meeting minutes from workshop(s) to discuss LCCA results. - Documentation of LCCA elements, with rationale for inclusion or exclusion. - Updated schedule and budget, with LCCA elements/impacts highlighted.

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

C) SUSTAINABILITY

Design Development

During the Design Development (DD) phase, the approved schematic design begins to include a level of detail necessary to work out a clear, coordinated description of all aspects of the project. The project team will review the LCCA elements incorporated to ensure that design conditions have not changed and that the LCCA return-on-investment calculations are still accurate.

Construction Documents/Permitting

During the Construction Documents (CD) phase, the project team prepares a comprehensive, fully coordinated set of construction documents and specifications to obtain the necessary permits and construct the project.

Construction

The objective of the Construction phase is to safely build the project as represented in the contract documents within the parameters approved by the University. There are no specific LCCA tasks or deliverables during this phase, unless new value engineering arises.

Closeout

Closeout entails the occupancy and turnover of the finished and fully commissioned project to the user group and Facilities Services Operations & Maintenance representative. It is important for building occupants and maintenance personnel to understand how their facility is designed to function, particularly as this relates to specific user behavior.

Operational (post Consultant Engagement)

The Operational phase begins once the initial project construction is complete and the building is handed over to FS O & M. During this period, key assumptions and anticipated outcomes established through LCCA studies need to be validated. As LCCA continues to evolve, the process for this evaluation will become more established and consistent.

Table 3C.06 Design Development

LCCA Tasks	LCCA Deliverables
• Project team reviews DD documents to ensure current design conforms to previous analysis.	• Documented review of LCCA elements, including design changes or LCCA modifications made during DD phase.

Table 3C.07 Construction Documents/Permitting

LCCA Tasks	LCCA Deliverables
• At 50% CD, FS Project Manager will ensure that contract documents are consistent with designs evaluated in original LCCA studies. • During bidding, the FS Project Manager will ensure that any Value Engineering (VE) options address the impacts on the LCCA elements.	• Documentation of changes made to LCCA elements as a result of VE process.

Table 3C.05 Closeout

LCCA Tasks	LCCA Deliverables
Project team will: • Ensure the Building Manager and FS O & M representative clearly understand specific user requirements associated with LCCA features (e.g., requirements that users control lights manually versus daylighting control systems). • Confirm that O&M manuals are complete and include any specific information related to LCCA elements in the building. • Ensure commissioning and training on systems highlight LCCA expectations for system performance, so that any significant variances can be identified. • During “lessons learned”, evaluate the LCCA process and experience	• Appropriate documents and training for building users and FS O & M representative related to the LCCA features in their building. • Documentation of LCCA “lessons learned” to be included in the eleven- month evaluation.

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

C) SUSTAINABILITY

c. Guidelines

The LCCA Procedure

The technical guidelines in this section are intended to establish adequate background and provide clear directions so that team members can implement LCCA studies effectively and consistently.

Designing for Minimum Life Cycle Costs

LCCA is a method of evaluating the cost-effectiveness of project design decisions. LCCA is comprehensive because it properly accounts for many project cost variables. These include a wide variety of project costs (construction, operations, maintenance, replacements, utilities, etc.). They also encompass the time value of money, including a project-specific discount rate, inflation and cost escalations for a variety of goods and services.

Performing an LCCA study involves:

- 1. Establishing objectives for the analysis,
- 2. Determining the criteria for evaluating alternatives,
- 3. Identifying and developing design alternatives
- 4. Gathering cost information, and
- 5. Developing a life cycle cost for each alternative.

1. Establish Objectives

To be successful, an LCCA study must have clear. LCCA can capture dollar cost variations between alternatives and show which option will have the lowest overall cost. It can only address values quantifiable in dollars. For example, an LCCA study of high-performance glazing can capture the overall cost-effectiveness of different options as compared to a base case. LCCA is not the right tool to evaluate improved occupant satisfaction with the different glazing products.

2. Determine LCCA Metrics

The two primary metrics to be used and calculated in LCCA are the life cycle costs of each alternative and its payback over a certain study life. That is, consideration should be given to total costs and the time it takes to recover an incremental initial investment incorporating the time value of money. When two alternatives have similar O&M costs over the study life, “first” costs (i.e., construction costs) will most likely drive the decision. This approach is further supported by the consideration of uncertainty (see below under Calculating Life Cycle Costs).

3. Identify the Base Case and Develop Alternate Designs

The LCCA approach is geared towards evaluating design alternatives. The alternative that captures the “standard” design or minimum requirements for a project is called the “base case”. The design team must develop alternatives to evaluate against the base case. These alternatives must be developed in sufficient detail to derive good cost estimates, which are required to run the life cycle cost calculations and to capture the incremental cost differences of the options.

The intent of these guidelines is not to develop an infinite number of alternates, but rather to capture as much cost benefit as possible given a reasonable amount of effort and investment. The goal should be to develop roughly one to five alternatives for a given building component. The design team should develop the alternatives, using its experience and judgment in selecting relevant building and system component options.

Analysis of alternatives should consider the effects of diminishing returns. Often, energy efficiency measures look less attractive in combination than when modeled individually. Where possible, effects should be calculated for each measure individually as well as for the measures in combination. For example, shading devices and high-performance glazing could each have a five- year payback, whereas the two combined may have a seven-year payback if they have a higher combined cost and address the same energy use issues.

4. Gather Cost Information

Cost information can come from a variety of source, including cost estimating consultants, contractors, vendors and designers.

For each alternative, gather all of the cost information described below under Cost Components of LCCA (e.g., construction, utility, maintenance, service, and in cases remodeling costs). Identify additional soft cost requirements for the alternatives as well.

Construction costs can be informed by recent University of Chicago projects. Utility and maintenance costs can be informed by Facility Services. Project Managers will manage the development of this information.

5. Perform Life Cycle Cost Calculations

For each alternative, calculate the metrics listed in Step 2 above, using the parameters listed under Life Cycle Cost Parameters below. Test each alternative against the two metrics and make a recommendation on which to incorporate into the design.

C) SUSTAINABILITY

Cost Components of LCCA

- Project costs
- Utility costs
- Maintenance costs
- Service costs
- Remodeling costs
- End-of-life costs

Project Costs

Project costs, often referred to as initial or first costs, include both “hard” or construction costs (labor, materials, equipment, furnishings, etc.) and “soft” costs (design fees, permit fees, etc.). Cost estimates and information from contractors, vendors and design teams can be used to develop project costs for LCCA alternatives.

In LCCA studies, the cost difference between alternates are usually what is important, not the absolute costs. Costs only need to be developed for the components that vary between alternatives. For example, in comparing two HVAC systems that have the same zonal equipment (e.g., VAV boxes) but varying central equipment (e.g., air handlers), the VAV box costs are ignored and only costs of the air handler developed. It is important to be thorough when considering cost variations between alternatives; all costs must be captured to make a valid comparison.

Utility Costs

a. Energy Costs

The majority of University of Chicago Facilities receives steam and chilled water from central plants. Electricity is distributed by Commonwealth Edison while generated by a number of producers. For each type of utility service there is a cost per unit of energy delivered that will be charged to the building. The rates for these utilities must be obtained from Facilities Services

b. Energy Estimating Methods

Typically the mechanical and/or electrical engineers on a design team will estimate the amount and rate of building energy use. The most comprehensive and widely used method of performing these estimates is energy modeling. If the level of effort needed should be evaluated on a case by case basis, simplified methods exist for estimating energy use. These include:

- Equivalent full-load hours
- Degree-day methods
- Outside temperature bin methods

c. Non-Energy Utility Costs

Domestic water and sewer service are two non-energy utility costs that need to be developed when affected by alternatives being modeled.

Maintenance Costs

Maintenance refers to the costs incurred to keep building system running properly. The wide array of activities performed by the University’s maintenance staff fall into four cost categories: preventive, reactive, planned and deferred. These data should be based on historic data provided by facilities operations.

a. Preventative Maintenance

Preventative maintenance is routine, scheduled activity intended to keep a system running at its best. This maintenance is performed whether or not there are any problems with a system. It is designed to prevent breakdowns. Changing filters and lubricating bearings are examples.

Preventative maintenance costs should be incorporated into LCCA calculations.

b. Reactive Maintenance

Reactive maintenance is performed in response to problems. If a fan belt breaks, for example, a technician issues a work order to replace the belt and address any associated damage to get the system running again.

Reactive maintenance is unpredictable. In theory, if systems are running well and all required preventive maintenance is performed, then reactive maintenance should be minimal. In practice, unplanned failures will occur and will require repairs.

For a project to retrofit an existing building that has ongoing reactive maintenance needs, the LCCA base case should include those costs, and the alternate can model reasonable and appropriate reductions.

c. Planned Maintenance

Planned maintenance refers to large-scale maintenance that is not addressed under preventative maintenance. It is the replacement of building subsystems at the end of their useful lives.

LCCA calculations expressly include planned maintenance in a form of replacement costs of equipment and systems. For example, if the time frame of a study is 30 years and a component of a mechanical system (e.g., a heat pump) needs to be replaced every 10 years, then the life cycle costs need to include the cost of that replacement at year 10, year 20 and year 30.

Factoring system and component replacement costs into LCCA calculations requires a number of assumptions about the useful life of these items. These assumptions should be clearly stated and documented so that they can be confirmed by the appropriate members of the Project Team..

d. Deferred Maintenance

Deferred maintenance represents a backlog of planned maintenance. It is the University’s goal to keep deferred maintenance to a minimum, but at present deferred maintenance does exist.

Deferred maintenance is not considered in LCCA for new buildings. For renovation projects, the deferred maintenance cost can be included in the base case. It should be addressed as appropriate for alternatives that reduce the maintenance needs in other ways, such as system or component replacement.

C) SUSTAINABILITY

Service Costs

Service costs include items such as janitorial services, pest control, and elevator maintenance. Since these costs depend more on the programmatic elements of a building than on the architecture, systems and other components, they are typically not considered in LCCA. However, they should be included if for some reason they differ among the design alternatives.

Remodeling Costs

Remodeling costs may or may not be included in LCCA depending on the specific building program. Typically they are not included, but some systems or components specifically require them (e.g., underfloor air delivery or wireless). It is within the Project Team’s discretion to decide whether and how to capture these costs.

End-of-Life Costs

a. Residual Value

Assume all buildings have zero residual value at the end of the study life. In the interest of keeping the initial LCCA studies as simple as possible, it will be used consistently across studies.

b. Demolition

Usually this cost is assigned to the new project on a site. When the extent or nature of the required demolition varies among alternatives, it is appropriate to include these costs.

REFERENCES

Refer to the University of Chicago’s Strategic Sustainability Plan.

D) ACCESSIBILITY & INCLUSIVE ACCOMMODATIONS

1. INTRODUCTION

This section includes accessibility requirements to be followed by the Consultant in the course of a project at the University of Chicago. The following standards apply to the design, documentation and implementation of accessibility for buildings and other structures included in the project, in addition to all required compliance with applicable laws, regulations, rules, codes, orders, judgments, and decrees. The University has developed these standards in an effort to anticipate accessibility needs not explicitly addressed by current legal requirements, which include dimensional standards to accommodate more users of larger wheelchairs and mobility devices.

In a continuing effort to advance universal design principles and make the campus usable to as many people as possible, the University of Chicago has adopted the term Accessibility Plus and expects its Consultants to exceed the minimum requirements for accessibility except where shown to be infeasible. See Section 4 of this chapter for Accessibility Plus Guidelines.

When conflicts arise among legal requirements, or between the Facilities Standards and legal requirements, the Consultant is expected to develop design solutions that provide for the greatest accessibility and usability while continuing to meet the legal requirements. Construction elements found to be nonconforming with requirements and standards will NOT be acceptable in the completed work. Remedial action will typically require total removal and replacement of affected work. The University, at its sole discretion, may request and consider other options for correcting nonconforming work, taking into consideration the effect that remediation efforts may have on the project construction time, cost, performance, and appearance.

The University’s Accessibility Design Review Committee (ADRC) reviews design documents for conformance with Accessibility Plus standards. Requests for exceptions to these guidelines may be submitted to the Accessibility Design Review Committee.

The academic or administrative unit responsible for the space may appeal a decision of the Accessibility Design Review Committee by submitting a written request to the Provost or designee.

Related sections of these Standards include:

- a. **General Design & Construction Requirements**
 - Temporary pedestrian circulation routes, accessible parking, signage, etc., around a construction site, incorporated into a Site Logistics Plan if required.
- b. **Heritage Resources**
 - Determine applicability of “historic building, structure or site” designation as it relates to the Heritage Resources program.
 - Determine applicability of “landmark” designation as it relates to the Heritage Resources program.
 - Determine whether the project includes alterations to buildings or facilities which are eligible for listing in the National Register of Historic Places under the National Historic Preservation Act, or designated as historic under State or local law.
- c. **Information Resources**
 - Coordinate compliance of signage, wayfinding and other communication elements with the University campus wayfinding/ signage guidelines and graphics program.
- d. **Vertical Transportation**
 - Coordinate elevator controls, signals, signage, platform lifts, cab sizes, clearances and other elements and features with University standards for vertical transportation.

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

D) ACCESSIBILITY & INCLUSIVE ACCOMMODATIONS

2. ACCESSIBILITY PROCESS

These Standards apply to the site, buildings, facilities and other elements that comprise each University project. Each project phase includes initiatives intended to increase compliance with accessibility requirements and objectives by integrating quality assurance measures into the Project Development & Delivery Process. The Consultant shall develop and implement a complete quality assurance/ quality control (QA/QC) program for accessibility on the project based on the requirements in these Standards. Consistent with this effort, the Consultant will also be responsible that the design and documentation for the project establish coordinated QA/QC requirements for the Contractor.

Reference Table D.01 for a more detailed outline of accessibility objectives during project phases.

a. Accessibility Plans

The Consultant shall include separate and distinct Accessibility Plans in the project drawings that clearly indicate project features of accessibility and universal design as they relate to the built environment. At a minimum, these shall include a site logistics plan, a site plan, and floor plans for each level of the project.

The Accessibility Plans are intended to serve as living documents that:

- Identify accessibility goals at the beginning of the project,
- Convey the primary accessibility requirements and features to the contractor and permitting agencies,
- Provide a baseline for verification and measurement of completed work, and
- Serve as a reference for building operations and future alterations to the building and site.

Elements to be included in the plans include, but are not limited to:

- Demarcation of project areas in plan according to the following categories:
 - New
 - Addition
 - Alteration and/or Repair
- Conditions of adjacent sites at project site boundary
 - Location of adjacent accessible paths (existing and proposed)
 - Grade elevations
- Accessible paths
 - Site – during construction/ phasing
 - Site – completed work
 - Site – accessible routes to the public way and as applicable, to public transportation stops
 - Building (in keeping with accessibility objectives, this will generally include most of the public and staff areas)
- Ramp/grade slope and cross-slope
- Curb cut ramps
- Turning space
 - Circular
 - T-shaped
- Clear floor space (including maneuvering clearances at doors and gates)
 - Forward approach
 - Parallel approach
 - Distance between doors in series
- Assembly area requirements
 - Seating
 - Assistive listening

- Accessible route clear width – straight run, passing and at turn
- High/low drinking fountains
- Toilet compartments and plumbing fixtures
- Storage/lockers
- Where required in alterations, all proposed and all completed improvements to the accessible path of travel

See Figures 3D.01 Typical Entry Level Floor Accessibility Route and 3D.02 Typical Floor Accessibility Route

D) ACCESSIBILITY & INCLUSIVE ACCOMMODATIONS

b. City of Chicago – Mayor’s Office for Persons with Disabilities (MOPD)

In accordance with current City of Chicago procedures, and depending on project complexity and whether modification to a Planned Development (PD) is required, a preliminary plan review with the City of Chicago MOPD may be required.

- The Project Manager and Consultant shall make this determination, and schedule the meeting at the appropriate time. In advance of the meeting, prepare a preliminary draft of the MOPD Project Data Form, include the following preliminary information:
 - Plan Development - [Yes/No]
 - Dwelling Units - [Type A/ Type B]
- The Consultant shall update the Project Data Form and schedule a follow up review of the Accessibility Plans and other design drawings with MOPD towards the end of the DD phase.
- Proposed improvements to the accessible path of travel when required in alterations, shall comply with Accessibility Plus standards, and be reviewed with MOPD.

D) ACCESSIBILITY & INCLUSIVE ACCOMMODATIONS

3. REQUIREMENTS

In addition to applicable codes and regulations, design the site, buildings, facilities and other elements of each project to meet the requirements of these Standards. The University has established certain Facilities Standards that exceed the legal requirements. In these instances, the Consultant is expected to meet the University’s standard, which will provide for greater accessibility. Where requirements in these Standards intentionally may exceed those of regulatory agencies, they are indicated with “**bold**” formatting.

a. Walking Surface Requirements

- Requirements shall include both interior and exterior accessible walking surfaces, unless noted otherwise.
- Walking surfaces of accessible routes shall be stable, firm and slip resistant.
 - Running slope (other than ramps) shall not be steeper than **1:25**.
 - Running slope for ramps shall not be steeper than **1:13**.
 - Cross slopes, including landings and maneuvering space, shall not be steeper than **1:67**.
- Walking surfaces should be as smooth as practicable. This includes localized variations in slope, as well as misalignment (lippage) between different adjoining finish materials, and between individual units (i.e. bricks, concrete unit pavers, wood slats, etc.). Both of these can present problems for users of wheelchairs and other mobility aids. The Consultant shall consider the individual and cumulative effects of the following on whole body vibration as established in ISO 2631:
 - Surface material
 - Gaps between units
 - Lippage between units
 - Unit pattern and direction relative to path of travel

- The Consultant shall select materials and design assemblies for walking surfaces that can be expected to maintain conformance with accessibility regulations and standards for many years with little or no maintenance.
 - Selection of materials and surface finishes should consider slip-resistance characteristics and long-term maintenance.
 - The use of unit pavers is **not** acceptable for the walking surfaces of exterior accessible routes unless the Consultant provides sufficient documentation that the design, construction and installation methods proposed will result in a surface that complies with applicable requirements for accessible ground surfaces including these standards, and can reasonably be maintained in compliance, under the use conditions specified for the project. Consideration should be given in selecting unit size and pattern to avoid conflict with accessibility objectives. Unless approved by the University Project Steering Committee, their use should be restricted to accent and ancillary areas of paving.
 - Asphalt concrete (asphalt pavement) is **not** acceptable for accessible walking surfaces on pedestrian paths. This exclusion is not intended to apply to exterior vehicular parking surfaces.
 - Stabilized, decomposed granite is **not** acceptable for accessible walking surfaces on pedestrian paths. The City of Chicago has determined that this material does not comply with standards for firmness, stability, and slip-resistance.
- Floor flatness requirements and suitability for the desired project finishes should be considered by the Consultant (including structural engineer) early in the project, paying special attention to areas where the accessibility requirements for flatness and slope apply.
- Thicknesses of finish materials and depth of the installed assembly must be considered to ensure that accessible spaces and accessible routes comply with all requirements for scope, flatness, and changes in elevation.

- Where a concrete substrate is planned, identify each area that is being designed to receive hard tile or stone.
 - Determine whether method of installation will utilize thinset or recessed mortar bed.
 - When specifying thinset installations, the Consultant shall be very clear about the flatness and surface finish requirements for the concrete substrate.
 - Prior to the end of the DD phase, clearly indicate the following areas in plan drawings:
 - Areas of the slab with recessed rough elevation. Coordinate the depth of the recess with the floor assembly design.
 - Areas of the slab with special flatness requirements. Include landing and ramps where applicable.
 - The Consultant shall review the unit size, pattern and joint sizes planned for the project, and determine the extent to which more stringent flatness requirements are appropriate to achieve the desired results.
 - Walking surfaces and detectable warning surfaces in the public way shall in addition conform with the requirements of the City of Chicago Department of Transportation (CDOT), including but not limited to:
 - CDOT Rules and Regulations For Construction In The Public Way
 - Appendix B, Requirements for Openings, Construction and Repair in the Public Way, ADA Standards
 - Approved Detectable Warning Tile, Product List

b. Ramp Requirements

- Provide in conformance with applicable codes and standards as a minimum standard for acceptance.
- The least possible slope shall be used for any ramp.
- Refer to walking surface requirements above for all landings and ramps.

c. Stair Requirements

- Provide in conformance with applicable codes and standards as a minimum standard for acceptance.

D) ACCESSIBILITY & INCLUSIVE ACCOMMODATIONS

- e. **Door and Hardware Requirements**
 - Where construction or alteration of a building entrance is performed, at least one entrance door complying with applicable accessibility standards shall be an automatic opening door equipped with approved access control systems.
 - Where alterations to primary function spaces require improvements to the existing accessible path of travel, or where required by applicable accessibility standards, at least one building entrance door complying with applicable accessibility regulations on the primary accessible path of travel shall be an automatic opening door equipped with approved access control systems, except where technically infeasible or disproportionate to the cost of the alterations, and with the approval of the University.
 - Where the primary accessible path of travel or accessible entrance to the facility consists of doors in series, at least one door of each in the series shall be an automatic opening door complying with applicable accessibility standards, and where required shall be equipped with approved access control systems.
 - Provide clearances at doors in conformance with applicable codes and standards as a minimum standard for acceptance.
 - In new construction the door opening force applies to areas or rooms that are accessible to the public and/or employees.
- Force for opening doors:
 - Interior side-hinged or pivoted-swinging door leaves:
 - Force required to open the door shall not exceed regulatory requirements; however, in no case shall exceed 5 lbf.
 - Not applicable to exterior doors, fire doors and doors to hazardous, mechanical service, or security observation areas.
 - Fire doors: In no case shall force required to open the door exceed the maximum allowable by the AHJ.
 - Exterior accessible entrance and vestibule doors: Force required to open the door shall not exceed regulatory requirements; however, in no case shall the manual pull or push on a door exceed 8.5 lbf in order to operate the door.
 - Exit doors in assembly units serving more than 200 persons shall be equipped with approved latches and bolts which release under a pressure not to exceed that required by the AHJ. The University is aware of a conflict among applicable codes and standards regarding operating forces for door hardware.
- Healthcare facilities have additional requirements that may not reflect these guidelines in all cases.
- Consider specifying self-closing assemblies and devices only where required or specifically programmed.
- Self-closing assemblies and closers to provide sufficient adjustment range to comply with accessibility requirements over usable life of the equipment.
- Unless otherwise directed, Consultant is to provide a QA/QC program that includes contractor verification and measurement including, but not limited to the following:
 - Doors shall be installed plumb, level and square.
 - Doors should open and close without binding, tightness, or stickiness from gaskets.
 - All hardware shall be adjusted to manufacturer’s specifications, with any damaged components replaced
 - Confirm design pressures for adjacent spaces through balancing, testing or commissioning of the ventilation system.
 - Subsequent to confirming design pressures, the Contractor shall measure the opening force at each door with a force pressure gauge.
 - Measure shall be taken using a force pressure gauge in conformance with code requirements. Use of a common “fish scale” gauge is unacceptable.
 - Take several measurements to verify that the readings do not vary widely.
- Record results by door number and include with the Accessibility Plans to be submitted prior to substantial completion.

D) ACCESSIBILITY & INCLUSIVE ACCOMMODATIONS

f. Drinking Fountain Requirements

- Determine the need for drinking fountains in the SD phase.
- Where drinking fountains are required or otherwise planned, each location shall have a combination high/low (standing/wheelchair) drinking fountain conforming to the requirements of applicable codes, including but not limited:
 - Spout location
 - Approach and clear floor space – 42” x 60” minimum unobstructed clear level floor space for forward or side approach at wheelchair accessible spout/basin.
 - Knee and toe space
- When located in accessible spaces or circulation paths, drinking fountains shall be recessed and conform to limitations for protruding objects.
- Elkay EZH20 bottle filling/drinking fountains or point-of-use filtrated water dispensers are preferred

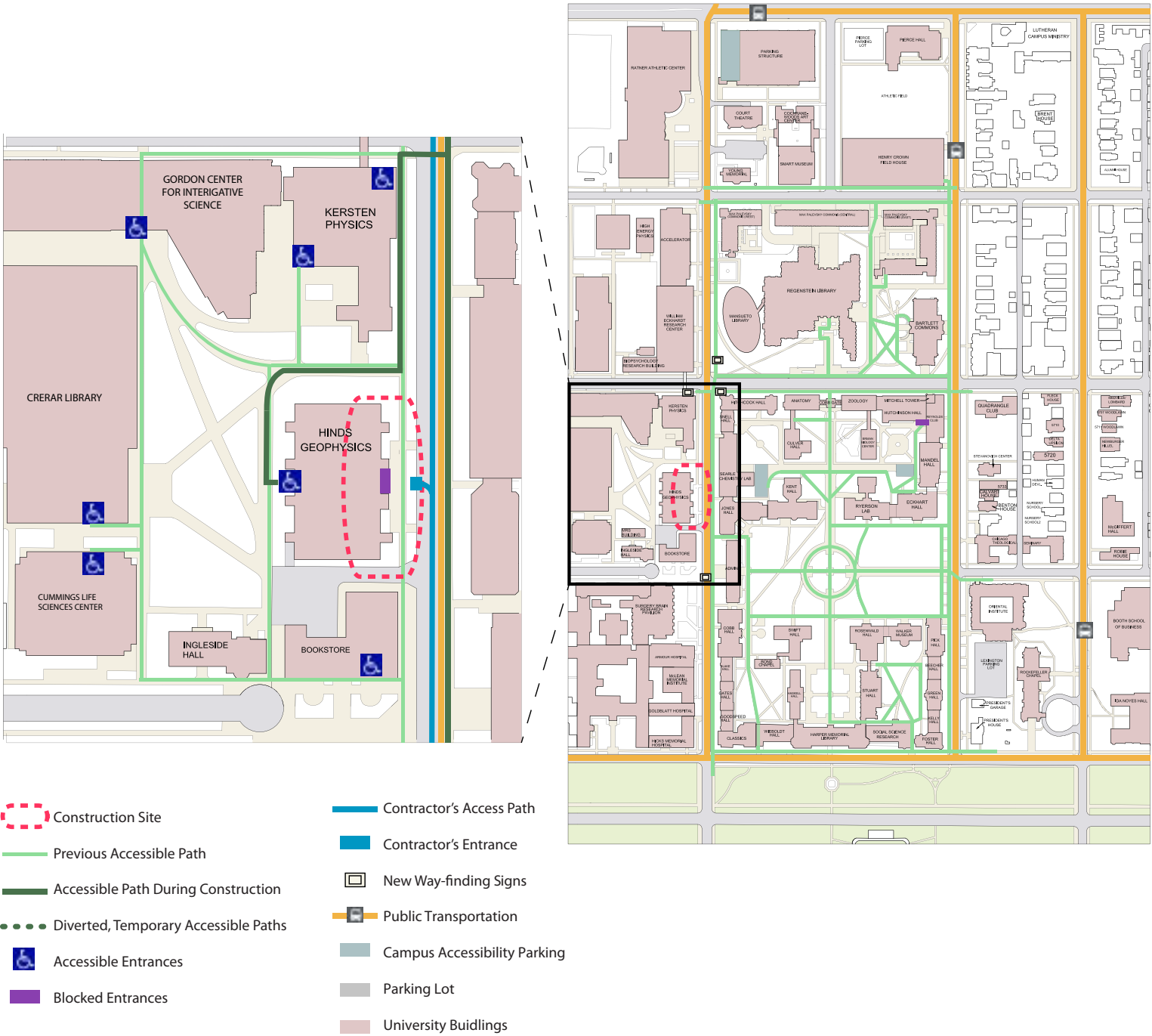
g. Elevator Requirements

- Conform to applicable codes and standards as a minimum standard for acceptance.
- Coordinate elevator controls, signals, signage, platform lifts, cab sizes, clearances and other elements and features with University Standards for vertical transportation.

h. Wayfinding/ Signage Requirements

- Conform to applicable codes and standards.
- The Consultant shall indicate the location and type of all code required signage in the Accessibility Plans.
- Site logistics/phasing plans shall indicate all necessary signage for alternate accessible routes during construction. See Figure 3D.04 Example Accessibility Plan for Construction.
- Coordinate compliance of signage, wayfinding and other communication elements and features with the University campus wayfinding/ signage guidelines and graphics program.
- See University Accessible Routes at maps.uchicago.edu.

FIGURE 3D.04 EXAMPLE ACCESSIBILITY PLAN FOR CONSTRUCTION



VOLUME III - DESIGN REQUIREMENTS

D) ACCESSIBILITY & INCLUSIVE ACCOMMODATIONS

FIGURE 3D.06 MINIMUM TWO-PERSON LAYOUTS

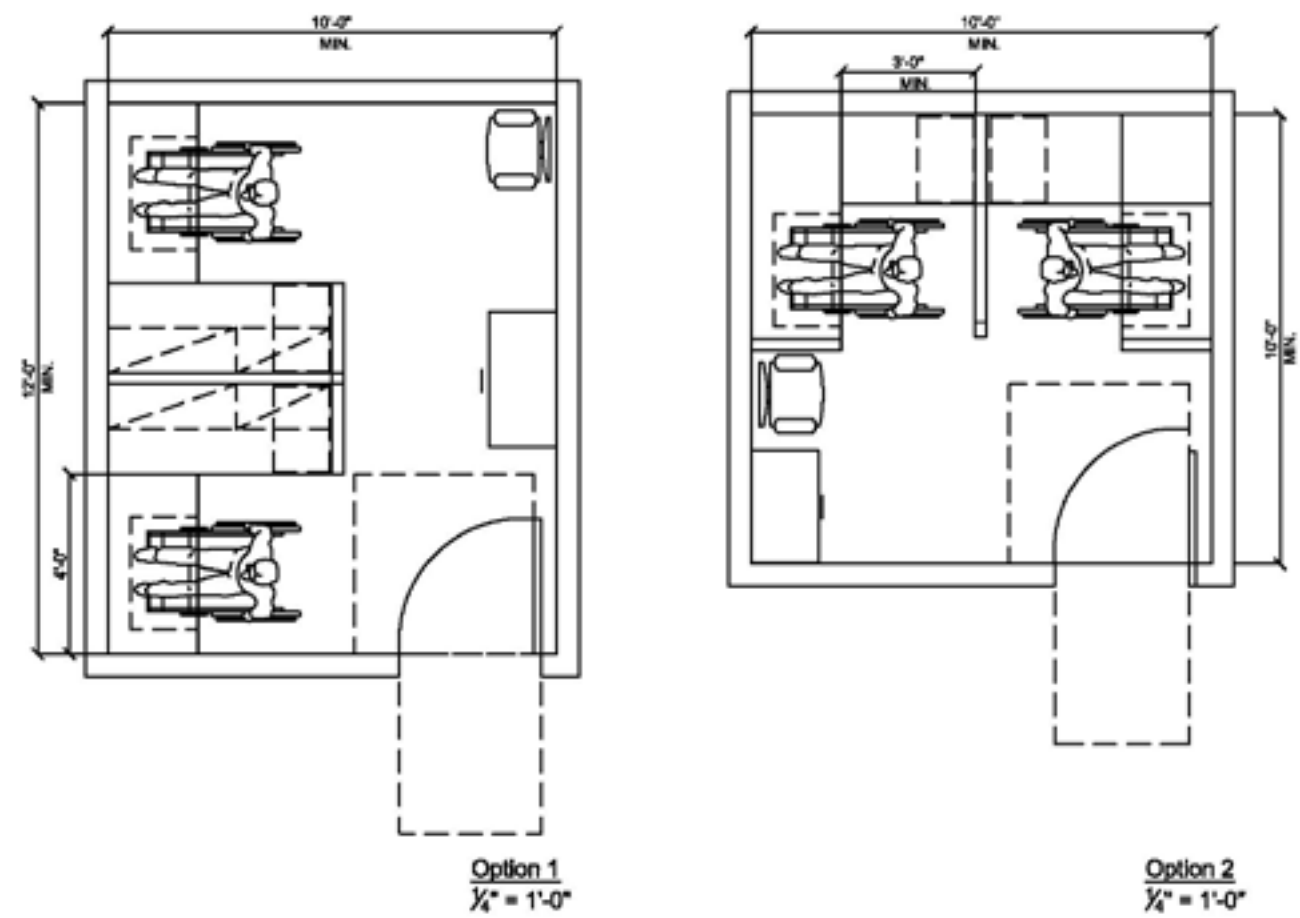
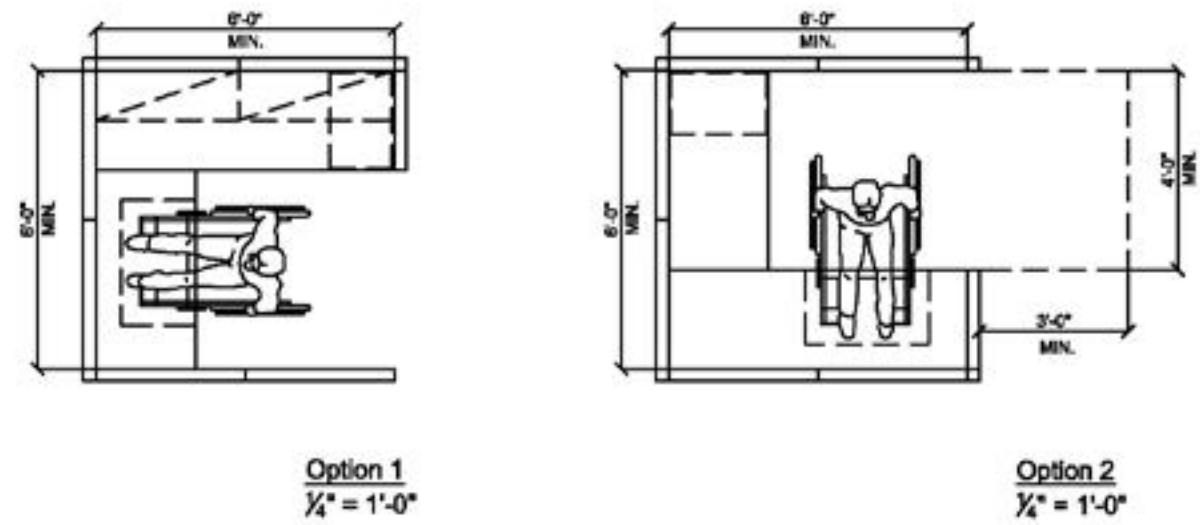


FIGURE 3D.07 MINIMUM OPEN OFFICE LAYOUT



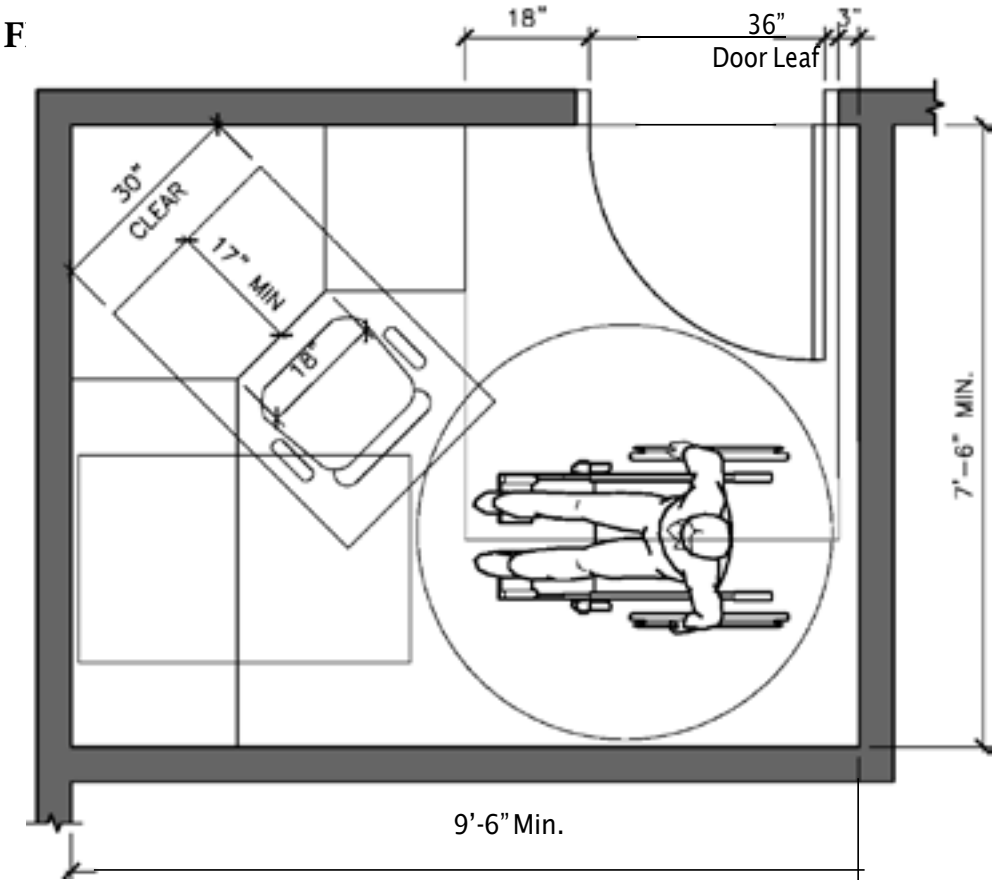
The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

D) ACCESSIBILITY & INCLUSIVE ACCOMMODATIONS

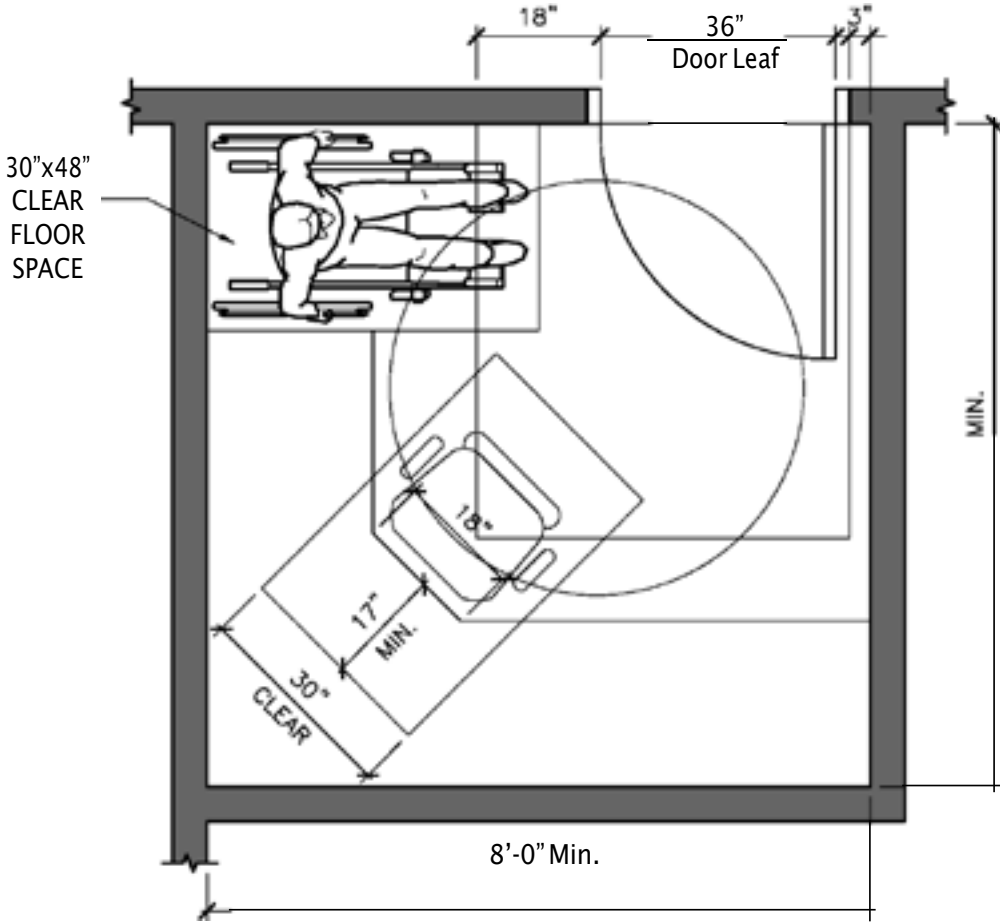
i. Minimum Office Size Requirements

- New and altered offices and work spaces shall meet or exceed the minimum size requirements for accessible offices and workspaces as referenced below:
 - Minimum Office Size Guidelines – Principles for Office Planning & Design.
 1. Each enclosed office space shall be designed to accommodate an occupant and one guest who use standard wheelchairs.
 2. Required maneuvering clearances shall be provided at all room entrances and exits and within workstations.
 3. Minimum unobstructed 60” diameter turning circle or 60” x 60” t-turn space is required. The turning space may extend under furniture if required knee clearances are provided or if the furniture is movable.
 4. Minimum 36” wide unobstructed accessible paths shall be provided within the space for occupants and visitors.
 5. Minimum 80” ceiling height and headroom clearance shall be provided.
 6. Fixed furniture and equipment shall be provided in compliance with reach ranges and knee clearances.
 7. Minimum clearances shall be provided for an arrangement of furniture appropriate to the assigned space use.
 8. All minimum clearances and dimensions shall be clear and unobstructed, and shall allow for conventional tolerances and variances in construction and manufacturing.
 9. Examples of layouts for single occupant offices, double occupant offices, and open offices that conform to these principles are provided. Examples assume a standard work surface depth of 17”-25”.
 - * For single and smaller offices refer to Project Design Program or Owners Project Requirements for guidance for AccessibilityPlus. Typically, AccessibilityPlus is not required for small offices.

- See Figures 3D.05 Minimum Office Size Guidelines and 3D.02 Minimum Two-Person Layouts and 3D.03 Minimum Open Office Layout
- The University of Chicago’s Accessibility Design Review Committee (ADRC) reviews design documents for conformance with Accessibility Plus standards. Requests for exceptions to these guidelines may be submitted to the Accessibility Design Review Committee.
- The academic or administrative unit responsible for the space may appeal a decision of the Accessibility Design Review Committee by submitting a written request to the Provost or designee.



Option 1
Minimum Office Size Guidelines
Reference Vol. IV BLANK for Accessibility Plus Standards



Option 2
Minimum Office Size Guidelines
Reference Vol. IV BLANK for Accessibility Plus Standards

D) ACCESSIBILITY & INCLUSIVE ACCOMMODATIONS

j) Parking Requirements

- Accessible car and van parking spaces shall conform to applicable codes and standards.

k) Construction and Manufacturing Tolerances

Federal, state and local accessibility codes generally make dimensional requirements subject to conventional industry construction and manufacturing tolerances. However, the subject of tolerances and methods of measurement has been an ongoing issue among building owners, architects, contractors and others when trying to meet the dimensional requirements of the ADA Accessibility Guidelines (ADAAG) and other regulations.

- In the absence of specific standards and methods for measurement established in the ADA/ABA Accessibility Guidelines, the Consultant shall include within the project construction Contract Documents, quality assurance requirements for verification, measurement, and applicable industry tolerance standards necessary to meet applicable regulations and achieve accessibility objectives. Incorporate applicable recommendations from publications by the US Access Board and other recognized industry sources, including but not limited to:
 - Initiative on Dimensional Tolerances in Construction Dimensional Tolerances for Surface Accessibility – Final Report, January 2011, by David Kent Ballast, Architectural Research Consulting

- Develop these quality assurance requirements prior to the end of the DD phase, and submit for review and acceptance by the FS Project Manager. Include the following in these requirements:
 - List applicable industry standards that define tolerances and measurement protocols.
 - Set requirements for independent testing agencies in measuring for compliance.
 - Where applicable, specify the method, protocols and measurement tools to be used to determine compliance with tolerances.
 - A two-foot digital level shall be specified as the designated method of measurement to determine acceptable slope and flatness unless otherwise indicated or approved by the University.
 - Indicate the general understanding that accumulated tolerances will not be accepted as justification for noncompliance of the completed work with accessibility regulations and Standards.

l. Performance Verification & Measurement

Determination of the degree and extent of performance verification and measurement (V&M) activities will be made by the University based on recommendations by the Consultant and other project team members. The extent of planned V&M activities will be re-evaluated periodically throughout the project based on the complexity and type of project.

- Materials, components and systems that are unique or have unproven records of performance shall be identified early in the project schedule so that suitable mockup testing and assessment can be made prior to the end of the Design Development (DD) phase. Changes to the design may be required for unproven systems.
- Where appropriate, more robust quality control measures may be implemented on the project to better ensure adherence to the desired performance requirements. These may include additional material testing, mockup testing, field testing, monitoring and measurement of the work on site.

m. Mockup Testing

Where mockup testing is included in the project V&M program, the project delivery method shall provide for the following:

- Retention of an independent Testing Agency.
- Provide all labor, materials, equipment and services required to install and test the designated full size mock-up(s) at the facilities of a recognized testing agency.

n. Field Observation

Where field observation is included in the project V&M program, the project delivery method shall provide for the following:

- Retain an independent Accessibility Consultant and/or Testing Agency to perform the field observations. To the extent practicable, they should be retained directly by the University.
- Determine the degree and extent of field observation appropriate to meet the project accessibility objectives. This can vary from periodic observations to full-time, on-site monitoring of the work.

o. Field Testing

Where field testing is included in the project V&M program, the project delivery method shall retain an independent Testing Agency to perform the field testing. To the extent practicable, the Testing Agency should be retained directly by the University.

- Guidance on the 2010 ADA Standards for Accessible Design – by the Department of Justice, September 15, 2010
- Fair Housing Amendments Act of 1988
- Section 504 of the Rehabilitation Act of 1973
- 2018 Illinois Accessibility Code (IAC)
 - 2018 IAC Deviation from the 2010 ADA Standards – by the Illinois Capital Development Board
- Chicago Construction Codes (Chicago Building Code - CBC)
 - ICC/ANSI A117.1-2009, with Chicago modifications
- City of Chicago, Department of Transportation (CDOT), Appendix B, Requirements for Openings, Construction and Repair in the Public Way, ADA Standards
- City of Chicago, Department of Transportation (CDOT), Approved Detectable Warning Tile, Product List

D) ACCESSIBILITY & INCLUSIVE ACCOMMODATIONS

4. ACCESSIBILITY PLUS GUIDELINES

The University expects Consultants to design new and altered building elements to meet higher standards of accessibility where feasible, including but not limited to the following priorities:

- a) Exterior public circulation routes and building approaches of no less than 60” in unobstructed width, and unobstructed level turning space no less than 98” in diameter;
- b) Primary building entrances with automatic doors, and no less than 42” in unobstructed width;
- c) Entrance level circulation routes, and routes to elevators and toilet rooms of no less than 42” in unobstructed width and unobstructed level turning space no less than 98” in diameter;
- d) Passenger and service elevators with no less than 42” unobstructed door opening width and cab size to accommodate an unobstructed turning circle no less than 98” in diameter – the design team may present alternative solutions that accommodate larger mobility devices and configurations for University review;
- e) No less than one area of rescue assistance and emergency refuge with at least one unobstructed level wheelchair space no less than 60” x 42”;
- f) A public, single-user toilet room on an accessible route with an automatic entrance door no less than 42” in unobstructed width and with an unobstructed level turning circle no less than 98” in diameter with no overlap with other fixtures or accessories;
- g) Not less than one office with an entrance door no less than 42” in unobstructed width and an unobstructed turning circle not less than 98” in diameter with no overlap with fixed furniture or equipment;
- h) Not less than one meeting/conference/seminar room with an entrance door no less than 42” in unobstructed width and a turning circle not less than 98” in diameter unobstructed with no overlap with fixed furniture or equipment.

5. ACCESSIBILITY REFERENCES

The Consultant shall be familiar with applicable federal, state and local regulations, and with current construction industry standards as applicable to the project design. Include those that are applicable in the design documentation for the project, and where appropriate indicate more stringent requirements as required to meet project goals. Unless otherwise required, the current editions and revisions of standards are applicable. Applicable federal, state and local codes and regulations include, but are not limited to:

- Revised regulations for Titles II and III of the Americans with Disabilities Act of 1990 (ADA) as published by the Department of Justice in the Federal Register on September 15, 2010.
- 2010 Standards for Accessible Design “2010 Standards” – by the Department of Justice, September 15, 2010
- Guidance on the 2010 ADA Standards for Accessible Design – by the Department of Justice, September 15, 2010
- Fair Housing Amendments Act of 1988
- Section 504 of the Rehabilitation Act of 1973
- 2018 Illinois Accessibility Code (IAC)
 - 2018 IAC Deviation from the 2010 ADA Standards – by the Illinois Capital Development Board
- Chicago Construction Codes (Chicago Building Code - CBC)
 - ICC/ANSI A117.1-2009, with Chicago modifications
- City of Chicago, Department of Transportation (CDOT), Appendix B, Requirements for Openings, Construction and Repair in the Public Way, ADA Standards
- City of Chicago, Department of Transportation (CDOT), Approved Detectable Warning Tile, Product List

D) ACCESSIBILITY & INCLUSIVE ACCOMMODATIONS

6. MINIMUM LACTATION STATION GUIDELINES

The The University of Chicago seeks to provide an environment suitable for employees and students to feed their infants and/or express milk. As such, the fundamental principles for lactation station renovation and construction are guided by Universal Design, which supports the creation of spaces that are inherently accessible to people both with and without disabilities.

The FS Project Manager, together with identified stakeholders, will determine the need to include a lactation space in the program for a given project.

The following list is to provide guidance in the planning and design of a lactation space. It is expected that the design of such a space meet or exceed Federal, State, and Municipal accessibility standards, codes, and ordinances.

In facilities where lactation spaces are provided, at least one lactation room or space, or no less than 5% of the total, in each room or facility, shall comply with the minimum accessibility requirements 4 through 12 below.

1. A room for nursing parents is a private space (other than a restroom) used to express milk. This space must be shielded from view and free from intrusion from others and therefore must be fully enclosed, with a locking entry door.
2. The lactation station space must be functional. There should be a place to sit and a flat surface, other than the floor, to place the breast pump (an optional requirement) and other supplies.
3. These spaces should provide access to electricity for the use of a breast pump, as well as good lighting, a comfortable temperature, and proper ventilation.
4. Each enclosed space shall be designed, at minimum, to accommodate an occupant who uses a standard wheelchair.
5. Required maneuvering clearances shall be provided at all room entrances and exits.
6. Minimum unobstructed 60” diameter turning circle or 60” x 60” t-turn space is required. The turning space may extend under furniture if required knee clearances are provided or if the furniture is movable.
7. Minimum 36” wide unobstructed accessible paths shall be provided within the space for occupants.
8. Minimum 80” ceiling height and headroom clearance shall be provided.
9. Minimum clearances shall be provided for an arrangement of furniture appropriate to the assigned space use.
- 10.Fixed furniture and equipment shall be provided in compliance with reach ranges and knee clearances.
- 11.All minimum clearances and dimensions shall be clear and unobstructed, and shall allow for conventional tolerances and variances in construction and manufacturing.
- 12.Provide visual fire alarm devices where required under the applicable codes and regulations.

7. LACTATION STATION REFERENCES

University of Chicago Human Resources:
<http://humanresources.uchicago.edu/fpg/policies/700/p706.shtml>

Additional references – University of Chicago Student Manual:
<https://studentmanual.sites.uchicago.edu/parents>

E) INFORMATION RESOURCES

1. INTRODUCTION

This portion of the Facility Standards includes information and data resources available to the Consultant at the start of their engagement, along with associated deliverables to be submitted in the course of a project at the University of Chicago. The FS Space Information Management Services (SIMS) group maintains this information and will coordinate these efforts through the FS Project Manager.

2. RESOURCE AND DELIVERABLES PROCESS

It is critical to the Facilities Services role within the University that accurate documentation of completed projects is available to service University facilities as well as initiate subsequent projects. As such, a process is required to continually maintain the University’s facilities drawings with multiple groups sharing responsibility. CAD drawing file formats are to be used following the current version of National CAD Standards, published by the AIA, CSI, & NIBS. Procedures and Project Deliverables for the SIMS group are defined in Table 3E.01.

3. REFERENCES

- CAD file formats are to be set up following the current version of National CAD Standards, published by the AIA, CSI, & NIBS. Specification formats are to follow current version of MasterFormat guidelines published by the CSI.
- University Policies or standards are available for reference in Volume IV of the facility and include Standards for Building Measurement, Room Numbering, External & Internal Building Signage, and F&A Office and Workstation Guidelines.

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

E) INFORMATION RESOURCES

Table 3E.01 Deliverables and Process Matrix

Deliverables	Responsibility	Details	Stage Due	Objectives / Comments
Project Data	FS Project Manager	Existing project backgrounds, surveys, utility information.	Project Initiation / Project Kick- off meeting	Provide extent of available project data for Consultant. Define deliverables, due dates, and responsibility. Confirm enforcement of requirements and Final Payment.
Room / Space Programming	Consultant	Final space program comparison to actual space provided	Schematic Design, review at subsequent Design Phases	Establish room or space sizes and departmental assignments. (SIMS / ARCHIBUS and “FICM”) “Room Type” designation is very important for reporting.
Room Numbering and Naming	Consultant		Schematic Design, review at subsequent Design Phases	Establish room numbering and naming consistent with SIMS standards.
Clean CAD Base Plans showing workstations, furniture and room identification	Consultant	Confirmed architectural as-built information (current National CAD Standards) including room numbers and room types	Bid Phase; Final drawings to be submitted again at substantial completion	For use by space database, operations setup, maintenance, orientation, signage, security, etc. Two submittals are required.
Building Information Models and Asset Data	Consultant	Building Asset data (following Section IV.E.8 in the Facilities Standards)	Developed through all project phases with final deliverables at closeout	For use by University operations, asset management, space database, and owner’s facility lifecycle management.
O&M Manuals - Searchable PDF files	Contractor	Including Guarantee / Warranty Materials, Testing, Inspections & Certifications, & Training Manuals	50% Construction Completion	All information is to be provided in time for Operations & Maintenance staff use
As-Built Shop Drawings (PDF)	Sub-Contractors	Following Current CSI format	30 days after Substantial Completion	
Record Photographs	Contractor		30 days after Substantial Completion	Manageable size, logical naming / folders
Record Drawings (PDF & CAD)	Consultant	All Disciplines	30 days after Substantial Completion	Compliance with National CAD Standard, published by AIA, CSI & NIBS, (also refer to Volume IV.F6 “Closeout Documents Guide”) Accessibility Plans - refer to Volume III Accessibility Section
Scope, Cost and Schedule Data (PDF)		Final cost summary, by account; final schedule of values submitted by GC; final schedule; final charter to provide project description and scope; final executive summary	Submit after final completion and once the final payments are processed and account closed	Required for input into the FS Cost Database and future reference
Information Quality Control	Facilities Services	Verify that electronic documents comply with requirements	30 days after Substantial Completion	Need audit routines, “file checkers”

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

F) SITE, CIVIL AND GROUNDS

1. INTRODUCTION & GUIDLINES

This portion of the Facility Standards includes guidelines for site, civil and grounds components to be followed by the Consultant during a project at the University of Chicago. Components covered in this document include:

- a. SITE SURVEY
- b. GEOTECHNICAL INVESTIGATION
- c. PAVING
- d. SIDEWALKS AND PATHWAYS
- e. SITE LIGHTING
- f. SITE FURNISHINGS
- g. FENCES AND GATES
- h. IRRIGATION
- i. CLIMBING VINES
- j. LANDSCAPE AND PLANTINGS
- k. UTILITIES
- l. DEMOLITION, SITE CLEARING AND EROSION CONTROL
- m. EARTHWORK

This portion of the (FS)2 document shall apply to the campus-wide site components listed above, from their point of origin or connection to the existing, to their entrances and terminations at buildings. This includes all exterior spaces on campus. The installation of campus-wide standards such as paving, benches, waste and recycle bins, and lighting will create and maintain a visual coherence and facilitate consistent long term maintenance. Repair and renovation projects as well as new construction will provide ample opportunities for these campus-wide standards to be implemented and all efforts should be made to do so.

a. SITE SURVEY

- 1. General
 - a. Due to the ever changing activities at the Campus, it is required that a site survey be performed for any project that will disrupt the existing ground.
- 2. Boundary Survey Requirements
 - a. Surveyor is required to retrace the boundary of the property and confirm Owner’s recorded legal description of the property.
 - b. Note identity, jurisdiction and width of adjoining streets and highways, width and type of pavement. Identify landmarks.
 - c. Show recorded or otherwise known adjacent property lines, easements and rights-of-way; state the owner of right of each. Show lines per last deed of record. Surveyor is not required to set corner monuments.
 - d. Provide a surveyor’s report to depict evidence of possible prescriptive Rights of Way in favor of or against subject site. Provide summary as to the nature of possible prescriptive Rights of Way in separate document.
 - e. Show zoning of property; if more than one zone, show the extent of each. Show zoning of adjacent properties and properties across adjacent street(s) or highway(s).
 - f. Show building line and setback requirements, if any.

3. Topographical and Situation Survey Requirements

The survey shall include all above ground improvements and natural features, as well as below grade improvements as described herein. The following are further descriptions and requirements:

- a. Plot location of buildings and structures within 0.10 feet.
 - i. Dimension perimeters in feet and decimals to 0.01 foot.
 - ii. State the character and general materials of structures.
 - iii. State the number of stories and elevation for each floor within survey limits.
 - iv. Dimension to property lines and other buildings.
 - v. Show encroachments, including cornices, belt courses, etc. either way across property lines.

- vi. List coordinates on all building corners, utility structures (at or above existing grade) and property corners.
- vii. Describe fences and walls, including height and type of construction. Identify walls and locate them with respect to property lines.
- b. Plot spot elevations and contours to meet or exceed requirements listed:
 - i. All elevations shall be to the nearest 0.01 foot.
 - ii. Provide contours at 1 foot intervals; error shall not exceed one half contour interval. Provide index contours at 5 foot intervals.
 - iii. Provide spot elevations at an approximate 50 foot square grid covering the property. Decrease grid spacing where necessary. Show all grade breaks, tops of bank, toe slopes, changes or edges of materials, manholes, etc.
 - iv. Spot elevations along streets, drive areas and intersections shall be at minimum 25 foot intervals. Decrease interval where necessary. Show all grade breaks. Indicate street crown if applicable, as well as top and bottom of curbs/ gutters and edges of sidewalks.
- c. Vacant parcels shall be noted VACANT.
- d. Show location, size, material (if available) and depth of all utilities, public and private. Utilize above ground information, underground utility markings, Owner record drawings, private locating services (if applicable) and other appropriate and available sources to obtain the most accurate information available, and incorporate data on survey. Note source of information on survey. Utilities include, but are not limited to, water, gas, electric, telephone, cable, fiber, steam, chilled water/hydronic, fuel oil and medical gases.
 - i. Locate all on-site fire hydrants as well as off-site hydrants if within 300’ of structures on the property. Indicate the size of the main serving each and the valve location. Locate post indicator valves and fire department connections whether free standing or attached to buildings.

SECTION F: SITE, CIVIL AND GROUNDS

- ii. Locate power and communications systems above and below grade. Research Owner documents to verify most accurate information available and incorporate data on survey. Note source of information. Provide minimum clearance dimension from overhead lines to ground.
- iii. Show location, size, depth, material and direction of flow of sanitary sewers, combination sewers, storm sewers and culverts serving, or on, the property; location of catch basins and manholes, and inverts of pipe at each. Research Owner documents to verify most accurate information available and incorporate data on survey.
- iv. Show location of underground tanks and septic fields.
- v. Provide name and address of the operating authority of each utility as well as contact person and phone number.
- e. Show flood plain, and or flood level of streams of adjacent bodies of water and analysis of site for potential flooding. Utilize flood insurance rate maps (FIRM) and other FEMA information to confirm this information.
- f. Show boundary of storm watershed area flowing onto the property from adjacent property. Provide small scale map to delineate boundary watershed area. Utilize USGS quadrangle maps or local contour maps to confirm this information.
- g. Locate Trees and Vegetation:
 - i. Locate trees of 2” caliper and greater (3’ above ground). Locate within 1’ tolerance and give species in English and botanical terms. Show approximate dripline of trees. Outline edges of heavily wooded areas. List elevations to nearest 0.01’.
 - ii. Indicate areas of planting / vegetation. Show outlines of areas where appropriate and describe nature of planting (i.e. mulch beds, ground cover, mixed plantings, hedges, etc).
- h. Provide an adequate number of permanent benchmarks with descriptions and elevations to nearest 0.01’.

4. Drawing Requirements

- a. Drawing sheets shall be trim size 24” X 36” with 1 ½” left binding edge and 1” borders.
- b. Drawings shall be at a scale of 1”=20’ or 1”=30’. All drawings shall be at the same scale. If an alternate scale is proposed, Surveyor shall state reasons for alternate in the proposal. Contact Architect/Engineer prior to preparing survey to coordinate and verify drawing scale.
- c. When survey has multiple sheets, include matchlines and a keymap on each sheet.
- d. Include graphic scale with each drawing.
- e. Show NORTH arrow and locate North to the top of the sheet.
- f. Include legend of symbols and abbreviations used on drawing(s).
- g. Boundary and topographic information, where both are required, shall be on the same drawing unless otherwise requested by the Architect/Engineer.
- h. State elevation datum on each drawing. Use North American Vertical Datum (NAVD-88). Give location of benchmark used.
- i. Furnish one reproducible transparency of each drawing. The Licensed Land Surveyor shall sign and seal drawing and shall certify that, to the best of the Surveyor’s knowledge, information and belief all information thereon is true and accurately shown.

F) SITE, CIVIL AND GROUNDS

b. GEOTECHNICAL INVESTIGATION

1. General

- a. All projects that have any earthwork activity shall have a geotechnical investigation completed or have soils information from a previous project available for reference.
- b. The Geo-Technical Report shall have information for design requirements related to earthwork activities which include the following:
 - i. Foundation bearing pressures
 - ii. Dewatering during and after construction
 - iii. Backfill material composition and placement
 - iv. Topsoil composition and placement
 - v. Soil Stabilization
 - vi. Testing and Inspection

2. Minimum Requirements

- a. The Geotechnical Consultant shall state in their proposal the coverages of professional liability insurance maintained for protection against claims arising from the performance of the professional services described herein. Qualified personnel under the supervision of a Registered Professional Engineer shall perform all work. All reports shall bear the seal of the Registered Professional Engineer. The proposal shall state a guaranteed date for completion of the report.

3. Sampling

- a. Benchmarks shall be established on the site and the boring elevations shall reference them. Alternately, boring elevations may be referenced to buildings referenced on the site plan if elevations are established for those buildings.
- b. Borings:
 - i. The location and depth of the borings proposed by the Geotechnical Consultant shall be shown on a sketch accompanying the Geotechnical Consultant’s proposal. If the Geotechnical Consultant finds it necessary to change the location or depth of any of these proposed borings, the Consultant shall be notified and a new location or depth shall be agreed upon between them. If unusual conditions are encountered, including but not limited to unanticipated materials, which cannot be penetrated by standard sampling equipment, the

Geotechnical Consultant shall immediately consult with the Consultant. The Geotechnical Consultant shall take such measures as are required to obtain the necessary information, subject to the Consultant’s approval.

- ii. The Geotechnical Consultant shall advise the Consultant as to any further exploration and testing required to obtain information that the Geotechnical Consultant requires for a professional interpretation of subsoil conditions at the building site, and shall perform such additional work as authorized by the University after consultation with the Consultant. The extent of exploration undertaken shall be consistent with the scope of the project indicated by the information given above and any drawings attached hereto. Sampling operations for both disturbed and undisturbed samples shall be in accordance with recommended American Society for Testing Materials (ASTM) Standards and other procedures, and as necessary to produce the information required for the Report(s).

4. Drilling and Sampling Methods

- a. Unless otherwise stipulated, drilling and sampling will be performed in accordance with current applicable ASTM Standards and other standards, including but not limited to ASTM Standards D1586, D1587 and D2113. Samples of soils shall be taken at the ground surface, at two feet below existing grade and at each identifiable change in condition, but not further apart than five feet in each of the borings unless otherwise specified on the boring drawing(s). Where clayey cohesive soils are encountered, thin-walled tube samples shall be taken of representative strata. Split-spoon samples shall be placed in sealed jars labeled with the following information: (1) boring numbers, (2) sample number, (3) sample depth, (4) blows per increment required to drive sample as per applicable standards, (5) date, (6) Project name, and (7) Geotechnical Consultant’s name.

- b. Rock cores (if appropriate) shall be not less than 1-1/8 inches in diameter, and shall be placed in core boxes properly labeled as indicated above.
- c. The sample shall be preserved and field logs prepared either by a Geotechnical Consultant or by an experienced Soil Technician acting under the supervision of a Geotechnical Consultant.
- d. The Geotechnical Consultant shall notify the Consultant before drilling equipment is removed from the site and advise the Consultant as to the field description of soil conditions encountered. The Geotechnical Consultant shall perform such additional borings or other exploration as may be authorized by the University after consultation with the Consultant.

5. Protection of Property

The Geotechnical Consultant shall contact the University and all utility companies for information regarding buried utilities and structures, and shall take all reasonable steps and precautions to restore the site to its existing condition prior to the Geotechnical Consultant’s entry. This restoration shall include, but not be limited to, backfilling of borings, patching of slabs and pavements, and repair of lawns and plantings. Each boring should be plugged temporarily, pending additional groundwater readings. At the completion of the groundwater readings, the borings shall be permanently plugged, including patching of slabs and pavements.

6. Coordination of Utilities

The Geotechnical Consultant is to include monies in his proposal to coordinate with the Surveyor and a location service for utilities to ensure that borings do not interfere with any existing utilities.

F) SITE, CIVIL AND GROUNDS

7. Field and Laboratory Report

- a. Format:
 - i. All segments of the reports covering the investigation and analyses shall be made on white letter size paper, available in pdf format. Written reports and analyses shall be on the Geotechnical Consultant’s letterhead.
 - ii. Larger drawings shall carry a title block which contains the Project name and location, the Geotechnical Consultant’s name and address, the date of the subsurface investigation, the date of the drawings, the initials of the person in charge of the crew making the investigation, the initials of the drafter, and the initials of the Professional Engineer who is responsible.
 - iii. All data required to be recorded according to the ASTM Standards or other standard test methods employed, shall be obtained, recorded in the field and referenced to boring numbers. Soils shall be classified in the field logs in accordance with current applicable ASTM Standards and other standards, including, but not limited to, ASTM Standard D2488. The classification for final logs shall be based on the field information, plus results of tests plus further inspection of samples in the laboratory by the Geotechnical Consultant preparing the reports.
- b. Include with the report a chart illustrating the soil classification criteria and the terminology and symbols used on the boring logs.
- c. Identify the ASTM Standards or other recognized standard sampling and test methods utilized.
- d. Provide a plot plan giving graphic locations of test borings, with the proposed building footprint super imposed.
- e. Provide vertical sections for each boring plotted and graphically presented showing of bores, sampling method used, date of start and finish, surface elevations, description of soil and thickness of each layer, depth of loss or gain of drilling fluid, hydraulic pressure required or number of blows per foot (N value) and, where applicable, depth to wet cave-in, depth to artesian head, groundwater elevation and time when water reading was made (repeat observation after 24 hours) and presence of gases.

- f. Note the location of strata containing organic materials, wet materials, or other inconsistencies that might affect engineering conclusions.
- g. Describe the existing surface conditions and summarize the subsurface conditions found to be present.
- h. Provide a profile and/or topographic map of rock or other bearing stratum.
- i. Analyze the probable variations in elevation and movements of subsurface water due to seasonal influences.
- j. Report all laboratory determinations of soil properties.
- k. Provide name of hydrologic soils group in accordance with Soil Conservation Service, Technical Release 55, dated June 1986, for each soil type found. Reports shall bear the seal and signature of a registered professional engineer.

8. Foundation Engineering and Recommendations

- a. The Geotechnical Consultant shall analyze the information developed by investigation or otherwise available to the Geotechnical Consultant, including those aspects of the subsurface conditions which may affect design and construction of proposed structures, and shall consult with the Consultant on the design and engineering requirements of the Project. Based on such analysis and consultation, the Geotechnical Consultant shall submit a professional evaluation and recommendations for the necessary areas of considerations, including but not limited to the following:
 - i. A determination of site class “A” through “F” as required by Section 1615 of the current edition of the International Building Code. Describe in the proposal how this evaluation will be made. Note that an aggressive evaluation of this parameter is required.
 - ii. Site specific values of the Short Period Spectral Response Acceleration (Ss) and the 1 Second Spectral Response Acceleration (S1) as shown in the current edition of the International Building Code.
 - iii. Foundation support of the structure and slabs, including soil bearing pressures, bearing elevations, foundation design recommendations and anticipated settlement.
 - iv. Anticipation of, and management of, groundwater for design of structures and pavements.

- v. Lateral earth pressures for design of walls below grade, including backfill, compaction and subdrainage, and their requirements.
- vi. Soil material and compaction requirements for site fill, construction backfill, and for the support of structures and pavements.
- vii. Pavement design.
- viii. Design criteria for temporary excavation and temporary protection such as excavation sheeting, underpinning and temporary dewatering systems.
- ix. Stability of slopes.
- x. Seismic activity.
- xi. Frost penetration depth and effect.
- xii. Analysis of the effect of weather and/or construction equipment on soil during construction.
- xiii. Analysis of soils to ascertain presence of potentially expansive, deleterious, chemically active or corrosive materials or conditions, or presence of gas.
- xiv. Evaluation of depth of material requiring rock excavation methods for removal.
- xv. Provide recommendations for the maximum safe slope from a new footing to another new or existing footing or structure, either higher or lower than the new footing.

F) SITE, CIVIL AND GROUNDS

c.1. PAVING: BUILDING ENTRANCES AND PLAZAS

1. General

a. Locations

- i. All building entrances, exits and plazas shall be provided with a non-slip, hard surface that meets the requirements as described in this section.
- ii. New access to existing buildings shall be designed in a manner that is accessible from the level of the surrounding grade, minimizing the required use of ramps, steps or other elevation transitions.
- iii. Access and paving widths shall be reviewed with FS Operations to confirm access and storage areas are adequate to facilitate snow removal.

b. Types

- i. Primary Entrance: a building’s main entrance that accommodates a majority of the building’s pedestrian traffic and is generally designed as part of the campus main corridor. A higher level of finish is desired for these locations.
- ii. Secondary Entrance: a building’s alternative access and can be considered an emergency, security or service entrance that is of a lesser use or other focus and is generally off the main campus corridor.
- iii. Emergency Exit: a required unobstructed access generally utilized to provide exiting for the building occupants.
- iv. Security Access: a building’s access that is monitored in some fashion.
- v. Plazas/Gathering Areas: an area outside of a building’s access area that is used to cue pedestrians for their next destination.

2. Design Standards

a. Widths

- i. Maneuvering zones at building entrances and exits shall be such that full operation of door swings can be accomplished and other devices can be located in a manner that prevents obstruction of the intended direction of traffic.
- ii. Refer to Sidewalks and Pathways Standards for access width requirements.
- iii. Refer to FS2 Volume III Section D – Accessibility for additional requirements.

b. Thickness

- i. Refer to Sidewalks and Pathways Standards for access thickness requirements.

c. Slopes and Drainage

- i. All Building Entrances and Exits shall slope away from the building to provide positive drainage to an adequate storm water collection device.
- ii. Accessible ramps (if approved) shall comply with the current Americans with Disability Act Accessibility Code (ADA), City, and University Accessibility Standards requirements.
- iii. Refer to FS2 Volume III Section D – Accessibility for additional requirements.

3. Construction Standards

- a. Building Entrance/Exit and Plaza surfaces shall be constructed of one or a combination of, the following materials:

- i. Cast in Place Concrete
- ii. Pavers (Granite, Sandstone, or Concrete), may incorporate permeable joints
- iii. Crushed Granite (Kafka Platinum Granite)
- iv. Refer to FS2 Volume III Section D – Accessibility for additional requirements.

- b. All exterior concrete to be constructed with a concrete mix containing a water/cement ratio of .40 (w/c=.40), six percent (6%) air-entrainment and a twenty eight (28) day compressive strength of 4000 psi.

- c. All exterior concrete is to be reinforced as specified by the American Concrete Institute (ACI) and the Concrete Reinforcing Steel Institute (CRSI) requirements.

- d. Tooled control joints shall be provided in all concrete flatwork to meet the requirements of the American Concrete Institute (ACI). Under no circumstance shall sections of concrete be jointed in a manner that will create small sections of concrete less than eight inches (8”) in any one direction.

- e. Expansion joints shall be located to meet the requirements of the American Concrete Institute (ACI) and at the following intervals that will match tooled jointing patterns.

- i. Flatwork up to eight (8) feet in width, no more than twenty-five (25) feet spacing in all directions.
- ii. Flatwork of larger width, no more than twenty (20) feet spacing in all directions.
- iii. Joints shall also be placed where sidewalks abut building walls, site walls, steps, around manhole and inlet structures and where indicated on the plans.

F) SITE, CIVIL AND GROUNDS

c.2. PAVING: PARKING LOTS

- 1. General
 - a. Locations
 - i. Parking lots shall be located and oriented in a manner that provides screening of vehicles from public and campus corridor ways.
 - ii. Landscape islands shall be provided as determined by the City of Chicago and as directed by Facilities Services and shall be no less than eight (8) feet wide.
 - iii. Landscape islands shall be organized to facilitate snow removal in the winter months and provide a means to slow and/or collect storm water runoff from the parking lot.
 - iv. Parking lots shall be located such that access by designated vehicles can be accomplished without excessive maneuvering in a public Right-Of-Way or other pedestrian, drive, street, or roadways.
 - v. Parking lots shall be provided with a non-slip, hard surface meeting the requirements as described in this section.
 - vi. Provide rolled curb conditions at locations adjacent to designated snow-pile areas to allow for snow removal from lots.
 - b. Types (this standard does NOT include Structured Garage Parking)
 - i. Regional Parking Lots
 - ii. Service Parking Lots
 - iii. Street Parking

2. Design Standards

- a. Parking Lots - Parking Space Sizes
 - i. Parking layout shall utilize the most efficient orientation for the given site constraints and limits. In no case shall a parking space be less than nine (9) feet wide and contain no less than one hundred eighty (180) square feet in area.
 - ii. Refer to the Americans with Disabilities Act (ADA) for accessible parking requirements.
- b. Access Aisles and Drives
 - i. Vehicle access aisles shall be of adequate width to allow for maneuvering and for safe traffic flow through the parking lot.
 - ii. Parking lot access drives shall be located such that vehicle stacking does not impede access to available parking spaces.
- c. Thickness
 - i. Refer to the Geotechnical Investigation to determine pavement design thickness and composition of materials.
- d. Slopes and Drainage
 - i. All Parking lot surfaces shall have a minimum slope of two percent (2%) and a maximum slope of three percent (3%) and be provided with positive drainage to an adequate storm water collection device.
 - ii. Maximize sheet flow to landscape islands as much as possible.
- e. Curbing and Pedestrian Access
 - i. All Parking lots shall be provided with a six inch (6”) tall by six inch (6”) wide concrete curb border and barrier around all planted islands. Refer to ADA requirements for curb ramps and accesses for accessible parking spaces.
 - ii. Pedestrian access shall be provided to a public way or as directed by Facilities Services.
 - iii. Refer to FS2 Volume III Section D – Accessibility for additional requirements.

3. Construction Standards

- a. Parking lot surfaces shall be constructed of one or a combination of, the following materials:
 - i. Asphalt
 - ii. Cast in Place Concrete
- b. Curbs / Curbs and Gutters shall be cast-in-place concrete.
 - i. Concrete curb surfaces shall have a dry rubbed finish on the exposed faces and be provided with expansion joints at the tangent points of all radii. No curb radius dimension shall be less than four feet (4’).
 - ii. Curb and Curb and Gutter profiles shall be as directed by the City of Chicago and Facilities Services.
- c. All exterior concrete shall be:
 - i. Constructed with a concrete mix containing a water/ cement ratio of .40 (w/c=.40), six percent (6%) air-entrainment and a twenty-eight (28) day compressive strength of 4000 psi.
 - ii. Reinforced as specified by the American Concrete Institute (ACI) and the Concrete Reinforcing Steel Institute (CRSI) requirements.

F) SITE, CIVIL AND GROUNDS

c.3. PAVING: STREETS AND DRIVES

1. General
- a. Locations
- i. In most cases, the Streets surrounding and within the Campus boundary are considered City Streets and are within a dedicated public Right-Of-Way (ROW) under the jurisdiction of the City of Chicago.

ii. Drives are considered private and shall follow these standards.

iii. Drives shall be routed in a manner that allows vehicular traffic to navigate through the Campus without causing a hazard or nuisance to surrounding properties or pedestrians and shall include landscaping.

iv. Crosswalks shall be provided at all pedestrian crossings with accessible ramps per the Americans with Disabilities Act Accessibility Code (ADA).

v. A sidewalk or other pedestrian way shall be provided on at least one (1) side of each street or drive. In most instances, a sidewalk shall be provided on both sides of the street or drive.

2. Design Standards - See table 3F.01
- a. Thickness: Refer to the Geotechnical Investigation to determine pavement design thickness and composition of materials.
- b. Slopes and Drainage: All Streets and Drives shall be crowned with a two percent (2%) slope, have a minimum longitudinal slope of two percent (2%) and a maximum longitudinal slope of three percent (3%) and be provided with positive drainage to adequate storm water collection devices.
- c. Curbing: All Streets and Drives shall be provided with a minimum six inch (6”) tall by six inch (6”) wide concrete curb border unless within the public Right-Of-Way. No curb radius dimension shall be less than four feet (4’).
- d. Driveway accesses and Street intersections shall be designed such that cross-slope transitions are provided with positive drainage on each side of a crosswalk.
- e. Driveway access at drive aisle transitions shall utilize a vertical curve design such that vehicles will not “bottom out” when traversing.

3. Construction Standards
- a. Curbs / Curb and Gutters shall be cast-in-place concrete.
- i. Concrete curb surfaces shall have a dry rubbed finish on the exposed faces and be provided with expansion joints at the tangent points of all radii.

ii. Curb and Curb and Gutter profiles shall be as directed by the City of Chicago and as directed by Facilities Services.
- b. All exterior concrete to be:
- i. Constructed with a concrete mix containing a water/cement ratio of .40 (w/c=.40), six percent (6%) air-entrainment and a twenty-eight (28) day compressive strength of 4000 psi.

ii. Reinforced as specified by the American Concrete Institute (ACI) and the Concrete Reinforcing Steel Institute (CRSI) requirements.

Table 3F.01 Streets and Drives

Type	Definition	Width	Paving Material	Loading Capacity
City Street	City of Chicago dedicated Right-of-Way	Per City of Chicago	Asphalt and/or Concrete	Per City of Chicago
Private Drive	Owned, maintained and operated by the University of Chicago	20’ min. for one-way; 24’ min. for two-way without parking; 36’ max for two-way with parking on one side. Parking is NOT allowed on both sides of street	Asphalt and/or Concrete	PerAASHTO-H20 Loading and Facilities Services Requirements
Service Drive	Private drive focused on access to service areas and equipment (fire trucks, utility and snow routes)	20’ min. for one-way, 24’ min. for two-way; provide accessible turn-around if clear exit is not attainable	Concrete	
Loading Dock / Dumpster Access Drive	Private drive focused on access to a loading dock or dumpster area			

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

F) SITE, CIVIL AND GROUNDS

d. SIDEWALKS AND PATHWAYS

1. General

a. Locations

- i. Sidewalks shall be located along vehicular and public ways in a manner that connect campus corridors and building entrances to public ways.
- iii. Sidewalks shall be accessible to pedestrians and shall comply with the current ADA Accessibility Code. Refer to FS2 Volume III Section D – Accessibility for additional requirements.
- ii. Sidewalks shall be located as directed by Facilities Services.
- iii. Sidewalks shall be located over steam tunnels or direct buried lines where possible.

b. Materials

- i. Cast in Place Concrete
- ii. Sandstone Pavers
- iii. Granite Pavers
- iv. Concrete Pavers
- v. Permeable Joint Pavers
- vi. Compacted Crushed Granite (Kafka Platinum Granite)

c. Slopes and Drainage

- i. All sidewalks and pathways shall be provided with positive drainage to an adequate storm water collection device.
- ii. All accessible paths and accessible ramps shall comply with the current Americans with Disability Act (ADA), City, and University Accessibility Standards requirements. Refer to FS2 Volume III Section D – Accessibility for additional requirements.

2. Design Standards - See table 3F.02

3. Construction Standards

- a. All exterior sidewalks to be constructed over a minimum 4” of compacted aggregate base on prepared subbase material unless noted otherwise.
 - i. Aggregate to be free of slag and deleterious materials and meet the gradation of Number 5 or Number 8 stone as classified by the State Department of Highway Specification.
- b. All exterior sidewalks that are concrete shall be constructed with a limestone mix consisting of a water/cement ratio of .40 (w/c=.40) and contain six percent (6%) air-entrainment with a twenty eight (28) day compressive strength of 4000 psi.
- c. All exterior sidewalks to be reinforced as specified by the American Concrete Institute (ACI) and the Concrete Reinforcing Steel Institute (CRSI) requirements.

- d. Sidewalks within the City Right-of-Way shall meet the requirements of the City of Chicago.
- e. Tooled control joints shall be provided in all concrete flatwork. Layout shall be as indicated on the plans.
- f. Expansion joints shall be located at the following intervals that match tooled jointing patterns.
 - i. Sidewalks up to eight (8) feet in width: no more than twenty-five (25) feet spacing in all directions.
 - ii. Sidewalks of larger width: no more than twenty (20) feet spacing in all directions.
 - iii. Joints shall also be placed where sidewalks abut building walls, site walls, steps, around manhole and inlet structures and where indicated on the plans.
- g. Exterior sidewalks to be finished with a transverse light broom finish.

Table 3F.02 Sidewalk and Pathway Standards

Type	Width	Concrete Thickness	Loading Capacity
Pedestrian sidewalk*	8’ min.	5” min.	up to 200 psf
Sidewalk with Fire Access	12’ min.	6” min.	400 to 500psf, AASHTO-H20 Loading
Heavy load sidewalk	8’ min.	8” min.	up to 1500psf loading. Loads exceeding 1500psf to have subbase evaluation
Pathways*	5’ min.	4” min.	up to 200 psf
Bicycle Path	5’ min.	5” min.	up to 200 psf
Tunnel top	match tunnel	4” min.	varies

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

F) SITE, CIVIL AND GROUNDS

e. SITE LIGHTING

1. General

a. Site lighting shall be provided throughout Campus as directed by Facilities Services.

b. Lighting may consist of a combination of light types including pedestrian pole lights, wall mounted lights, street lights, etc.
2. Design Standards - See table 3F.03

a. Illumination Levels

i. A minimum lighting level of 0.5 footcandles shall be provided in all areas of the Campus. Light levels greatly exceeding this are generally not desired, the goals is to maintain a consistent level of footcandles that meets the minimum level requirements throughout campus.

ii. Street lighting shall comply with the City of Chicago standards.

b. Spacing / Location

i. Locate the centerline of site lighting fixtures 18” off the curb or the edge of the sidewalk

ii. Parking lot lighting shall be located in islands or along perimeter to prevent damage by parked or moving vehicles.
3. Construction Standards

a. Lighting shall be installed per manufacturer’s recommendation. Incorporate appropriate footing; note specific visible base detail for the Oxford Light Poles and consult FS for the custom concrete frame. See Figure 3F.04.

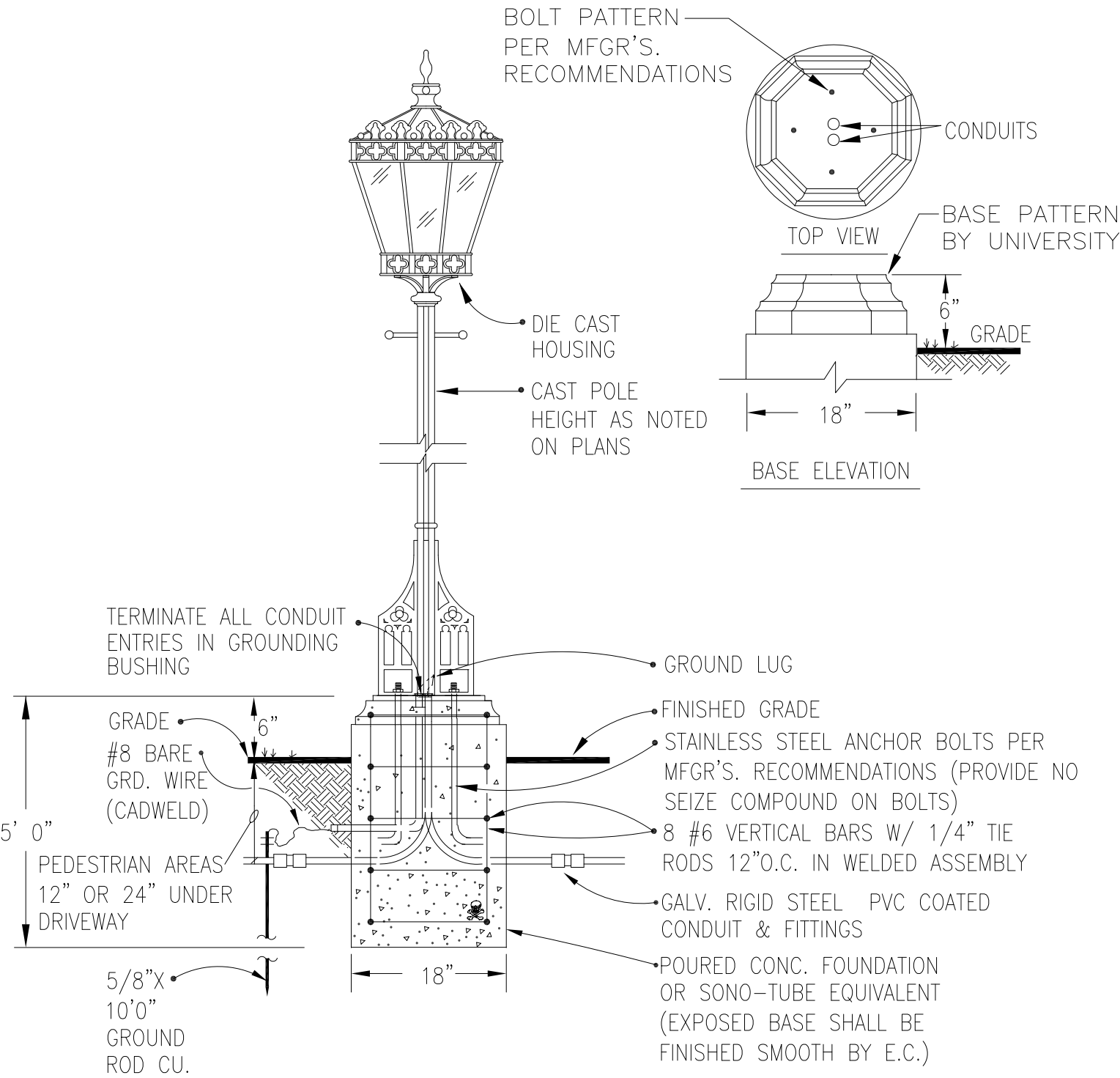
b. All new lighting shall be connected to the Building Automation system (BAS).

Table 3F.03 Campus Exterior Lighting

Type	Product	Manufacturer	Voltage / Kelvin	Color	Specifications	Notes	Additional Functions
Pedestrian Pole	Oxford Light: CD-7718	St. Louis Antique Lighting Company	Retrofitted with: 27W LED / 3000K	Satin Black	Lights shall be shipped without the lamp and retrofitted by FS Electric Shop as defined in this table including E26 base, 100-277V. This must be coordinated with Electric Shop prior to ordering the lights	Used in Historic Campus Areas; SEE FIGURE 3F.04	All new poles shall have an electrical outlet; where applicable, include a security camera - review with campus Landscape Architect and Department of Safety and Security
	Albertslund Mini Post	Louis Poulsen	42W LED / 4000K	Graphite; Touch-up paint use RAL-7022	Pole Height: 12’ Distribution / Trim: BUG U3; Pole Transition: T-DRA-5IN-3IN; Light Control: Dim 0-10V; Variant: 10000147969	Used in all other areas of campus	
Path Lights	Model subject to architectural context		LED, match surrounding Kelvin	Black or Graphite (match context)	Design should be minimal, durable, and complementary to context	Only used when other light types are insufficient; review with campus LA prior to pursuing	
Bollard Lights	Not Recommended - review with campus Landscape Architect prior to pursuing a bollard light						
Uplights	Bullet Style Uplight		LED, match surrounding Kelvin	Black or Graphite (match context)	Design should be minimal, durable, and complementary to context; ensure light direction does not cause glare issues	Used minimally for tree accent lighting and additional ambient light; review with campus LA prior to pursuing	
	Bar Style Uplight		LED, match surrounding Kelvin	Black or Graphite (match context)	Design should be minimal, durable, and complementary to context; ensure light direction does not cause glare issues	Review with campus Architect and Landscape Architect prior to pursuing	include hood if applicable to reduce glare
Wall-Mounted Exterior Lights	Salisbury 29” single light wall light	Kichler	LED, match surrounding Kelvin	Black	9043BK	Historic Campus Areas, review with campus Architect and Landscape Architect prior to pursuing	
	Model subject to architectural context		LED, match surrounding Kelvin	Black or Graphite (match context)	Design should be minimal, durable, and complementary to context	All other campus areas, review with campus Architect and Landscape Architect prior to pursuing	

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

Figure 3F.04 Oxford Light Pole Base



Oxford Fixture, Model CD-7718

NO SCALE

F) SITE, CIVIL AND GROUNDS

f. SITE FURNISHINGS

1. General - See table 3F.05
- a. Location
- i. The proposed location and use of any site furnishings must be approved by Facilities Services prior to purchase and installation.
2. Construction Standards
- a. General
- i. Refer to manufacturer’s recommendations for installation, warranty and maintenance requirements.

g. FENCES AND GATES

1. General
- a. Locations
- i. Fences and Gates shall be located as directed by Facilities Services.
- ii. Fencing / Screening shall be provided around dumpster enclosures and loading areas.
- iii. This standard does NOT include construction fencing.
- b. Types
- i. Decorative/Historic Fence-black metal fence with gates.
- ii. Security Fence-six (6) feet tall chain-link fence with gates.
2. Design Standards
- a. Existing Conditions
- i. Where existing fencing is in place:
- (1) Reuse historic ornamental fences and gates wherever possible. If reuse is not possible, donate or salvage. Refer to the demolition section within this document for additional information.
- (2) New fencing material is to match the existing fencing in height, color, design, profile and style.
- (3) Transition new fencing into existing fencing in a manner that will provide a consistent fence line.
- b. New Conditions
- i. Refer to Facilities Services for types of fencing to be provided. Design to relate to project scale and architecture.
3. Construction Standards
- a. All fencing shall be installed per manufacturer’s recommendations.

Table 3F.05 Campus Exterior Furnishings

Type	Product	Manufacturer	Specifications	Color	Additional Notes
Benches	Windermere Bench	Country Casual	With arms, with mounting hardware typical	Unfinished Teak	Main Campus
	FGP Bench	Landscape Forms	70” length; backed typical; backless in select areas; surface mount typical	Ipe wood, Mercury Frame	Campus South Only
Lounge Tables and Chairs	Cochran Lounge Chair	Landscape Forms		Black Frame and Fabric	Must be approved by campus Landscape Architect prior to specification
	Cochran Side Table	Landscape Forms	Custom base mount tabs if needed	Black Frame and Tabletop	
Dining Tables and Chairs	Parc Centre Chair	Landscape Forms	Armless, typical	Mercury	36” round Chipman Table acceptable if larger table is required
	Parc Centre Table	Landscape Forms	30” round	Mercury	
Picnic Tables	Charlie Table	Landscape Forms	67” table, no umbrella hole	Mercury	surface mount, typical
Chaise Loungers	Chill Lounge Chair	Landscape Forms		Warm Gray (Otter); red for Crerar Quad ONLY	Must be approved by campus Landscape Architect prior to specification
Bicycle Racks	Bike Dock	Saris Infrastructure		Powdercoated Black	Preferred by Users
	Wave Rack		Model dependent on space and capacity requirements	Powdercoated Black	Better to Maximize Capacity
	Bike Rack	Reliance Foundry	R-8212-SS; surface mount	316 stainless steel	Upgraded Standard
	Wave Rack		five or seven-bike capacity: R-8239-SS or R-8240-SS; surface mount	316 stainless steel	Upgraded Standard
Trash and Recycling	Ironsites S-42	Victor Stanley	domed lid; black plastic liner	Powdercoated Black, Typical; Campus South: Powdercoated Gray	All receptacles must be coordinated with FS Operations prior to specification and installation. Trash and Recycling must come as a pair.
	Ironsites S-42		Recycle lid (white text / logos); black plastic liner		
	Solar Intelligent Waste & Recycling Collection System	Big Belly	Bigbelly HC5 (High Capacity)	Black	Must be confirmed with FS Operations prior to specification - long term costs and specific operations requirements
Smoking and Ash Urns	Penn Ash Tower	Keystone Ridge	1 quart, surface mount	Black	Only to be provided in areas pre-approved by FS

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

F) SITE, CIVIL AND GROUNDS

h. IRRIGATION

- 1. General
 - a. Locations
 - i. All lawn and planting areas shall be provided with a complete underground irrigation system.
 - ii. Irrigation system shall be tapped from an existing water supply and shall include RPZ device.
 - iii. Irrigation system shall be equipped with a Mini click rain sensor.
 - iv. Irrigation timers, clocks, etc., shall be mounted discretely on exterior of buildings or freestanding.
 - b. Types
 - i. Broadcast system with rotor spray heads and fixed spray heads.
 - ii. Mist system
 - iii. Drip irrigation shall not be used on campus.
 - iv. Automatic systems and/or Manual systems
 - c. Acceptable Manufacturer: Hunter Industries, Inc.
- 2. Design Standards
 - a. The irrigation system shall use sprinklers, valves, piping, fittings, controllers, wiring, pumps, etc..., of sizes and types as required to provide one hundred percent (100%) coverage of the area.
 - b. Irrigation water will not be permitted to spray on sides of buildings, sidewalks, paths or roadways.
 - c. Controllers shall be located in the vicinity of the specific irrigated area and be accessible at all times. Smart, weather sensing controllers must be used.
 - d. All valves and splices shall be installed in valve boxes and be accessible at all times.
 - e. Shop drawings showing the complete layout of the irrigation system shall be submitted to Facilities Services for review prior to installation.
 - f. A detectable warning tape, tone wire, or other device shall be provided in the trench to locate irrigation distribution lines below grade.

3. Construction Standards

- a. Pipe and Joints
 - i. Mainlines shall be SDR 21 or 26 PVC pipe with schedule 40 fittings.
 - ii. S ection lines shall be 80 psi polyethylene pipe with two (2) Oteker clamps at each side of the fitting.
 - iii. Western Brass shall be used for 1” pipe quick connect valves (QCV) and be located in 10” valve boxes.
 - iv. Swing joints to be provided for 1” PVC QCV.
 - v. Minimum depth of all pipes shall be at least 12” below surface.
 - vi. All piping under paved surfaces and walks shall be sleeved.
- b. Heads
 - i. Turf and high pop mist heads to be Hunter Pro Series.
 - ii. Rotary heads to be Hunter PGP Ultra.
 - iii. Swing pipe and fittings will be used for all ½” and ¾” heads.
- c. Wiring: Control wiring to be 16 gauge solid copper or 18/13 multi wire with #14 ground.
- d. Clocks: Clocks shall be Hunter ACC model and interface with the IMMS central control system by means of a LAN or radio and antenna unit.

i. CLIMBING VINES

- 1. Description:
 - a. The image of the University is enhanced by its ivy-covered buildings on the Main Quadrangles. The University encourages the protection of and continued planting of vines on or next to appropriate building walls. The benefits of the correct species of vines include:
 - i. Cooling of building in summer months
 - ii. Protection of building from UV rays
 - iii. Absorption of air impurities by plant material
 - iv. Increasing productivity and mood of building users
 - v. Reduced exterior noise
- 2. Design
 - a. Considerations for protection of or introduction of vines on projects are to be outlined as part of the design phases with enough detail to describe species, protection techniques, planting techniques, maintenance considerations, integration with Bird Safe Building guidelines and integration with other landscaping.
 - b. Highly ornamental facades should not have vines introduced as plantings that would cover the ornamental nature of the architecture. Ivy should only be permitted on planar walls where acceptable.
 - c. Vine species shall be selected to ensure they are non-invasive and their climbing style is appropriate for the structure they will be climbing. Recommended species: Parthenocissus tricuspidata (Boston Ivy)
- 3. Maintenance
 - a. Buildings with vine plantings should be regularly pruned to ensure vines do not extend beyond the intended areas or cover elements such as signs, windows, vents, access panels, doors, or architectural ornament.

F) SITE, CIVIL AND GROUNDS

j. LANDSCAPE AND PLANTINGS

- 1. General
 - a. Campus landscaping should be simple and clean in design, reinforce the scale and context of the area in which they are located, contribute to the University’s Botanic garden initiative, and consider ease of maintenance for long term plant viability.
 - b. All existing trees are to be preserved wherever possible; any work requiring tree removal or pruning must be reviewed with campus Landscape Architect for approval.
 - c. Building entrances and Plazas should have plantings with variety and interest whereas building plantings should soften the foundation areas.
 - d. Parking lot plantings should be shade trees in which canopies will cover the paved surface and provide thermal shading (heat island effect) as well as rainfall interception.
 - e. Interior plazas and courtyard areas should be designed with extra consideration for maintenance access.
 - f. Plantings should be coordinated with site lighting to not diminish lighting levels for security reasons.
 - g. Planting areas shall be located and configured such that impacts to underground utilities from planting root systems are minimal.
 - h. Native / Naturalized durable and low maintenance plant species shall be used to the greatest extent possible to ensure long term plant viability and reduce irrigation requirements.
 - i. The use of annuals shall be minimal and constrained only to use where other permanent plantings is not appropriate.
 - j. Where applicable, landscape material and placement shall meet the City of Chicago landscape standards.

2. Design Standards

- a. Selection Criteria
 - i. Minimal and easy maintenance is desirable for all plantings.
 - ii. Wherever possible and practical, plant material should be drought tolerant and require minimal irrigation.
 - iii. Landscape design should consider seasonal changes and incorporate plant material with winter interest.
 - iv. Ability to resist disease and insect infestation should be considered.
 - v. Select plants with appropriate plant hardiness zones
- b. Selection of Plantings
 - i. All plantings will be specimen quality and shall be tagged at the nursery by the design Landscape Architect and a member of Facilities Services to assure the hardiest and most tolerant plant is selected.
 - ii. All lawn areas shall be seeded or sodded with the appropriate seed mixture as directed by Facilities Services.
- c. Warranty and Maintenance
 - i. Maintenance shall commence immediately after plant material is installed and continue for a minimum of 60 days after Substantial Completion.
Maintenance consists of the following:
 - Watering
 - Fertilizing
 - Weeding
 - Trimming
 - Replanting
 - Other operations to provide a healthy landscape

3. Construction Standards

- a. Materials
 - i. Material shall be the quality, size, genus, species, and variety of trees and shrubs indicated, complying with applicable requirements of ANSI Z60.1-“American Standard for Nursery Stock”.
 - ii. All planting material shall be certified by the State or Federal Department of Agriculture to be free of hazardous insects or apparent disease.
 - iii. All planting material shall have a certificate that states the material is the species specified.
- b. Delivery and Storage
 - i. Coordinate storage of plant material with Facilities Services prior to delivery if adequate room is not available within the construction limits.
- b. Grass Seed Mixtures: See table 3F.06

F) SITE, CIVIL AND GROUNDS

Table 3F.06 Grass Seed Mixtures

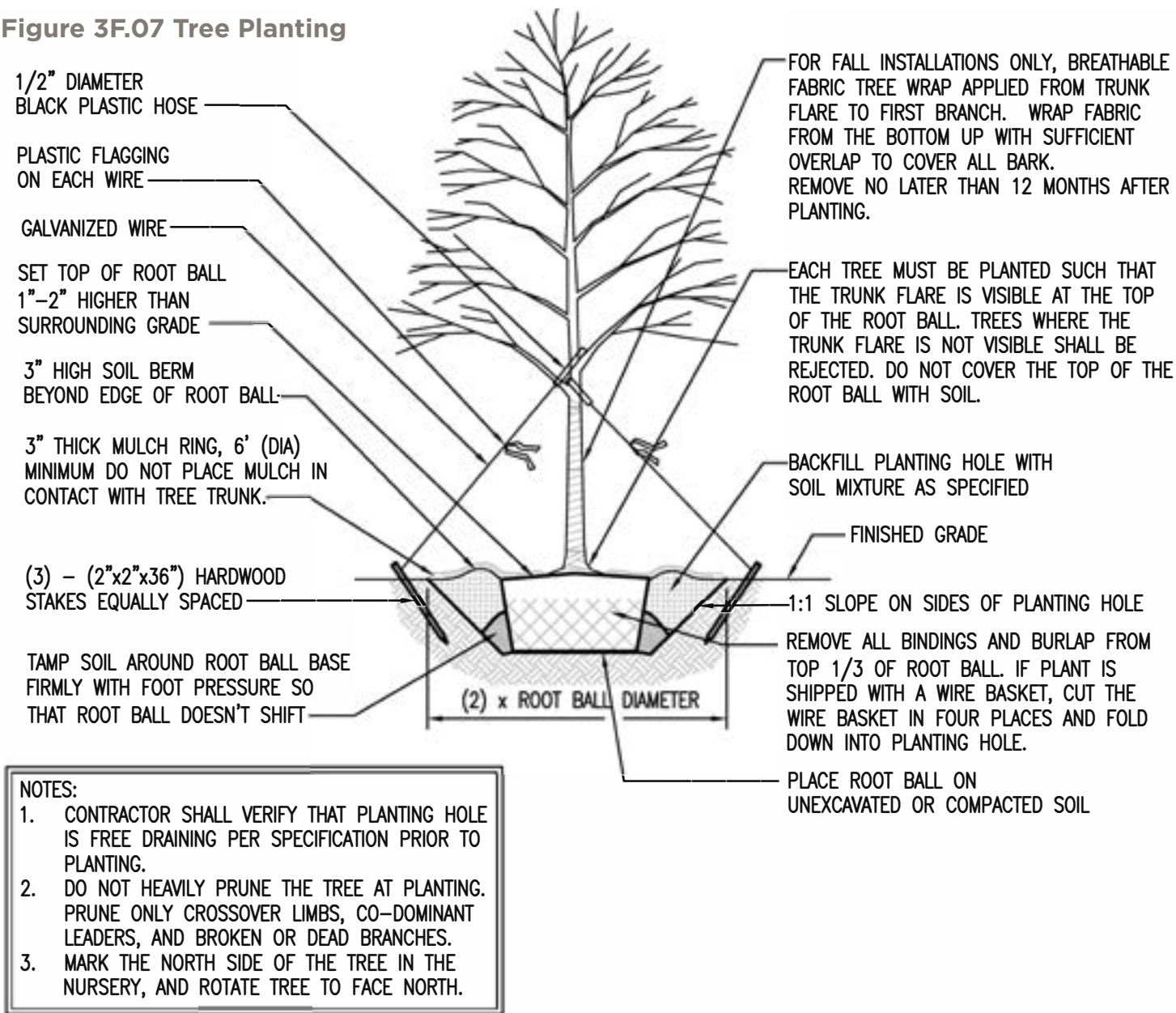
Type	Seed Mix Name	Maker	Mixture	Notes
General Seeding	Field of Dreams Gameday Grass	National Seed	19.95% Freedom III KY Bluegrass 19.93% NuBlue Plus KY Bluegrass 19.85% Blue Chip Plus KY Bluegrass 14.72% Top Gun 2 Perennial Ryegrass 14.61% Accent Perennial Ryegrass 09.94% Diva KY Bluegrass	(full sun to part shade)
Shade	Greenskeeper Premium Shady Grass	National Seed	40% Creeping Red Fescue 30% Monterey 3 Perennial Ryegrass 20% Culumbra 2 Chewings Fescue 10% Nu Blue KY Bluegrass	
Parkways and Pavement Edges	University of Chicago Maroon Mixture	National Seed	20% Fults Distans Alkailigrass 20% Palme V Perennial Ryegrass 20% Freedom III KY Bluegrass 20% Blue Chip Plus KY Bluegrass 20% Creeping Red Fescue	
Athletic Fields	Premium Athletic Mixture	John Deere Landscapes	35% Excursion KY Bluegrass 20% Award KY Bluegrass 15% Gladstone KY Bluegrass 15% Manhattan Perennial Ryegrass 15% Prototype Perennial Ryegrass	
Low-Mow	Greenskeepers National Links Mix	National Seed	25% Creeping Red Fescue 25% Sheep Fescue 25% Chewings Fescue 25% Hard Fescue	10-12” when left unmowed

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

F) SITE, CIVIL AND GROUNDS

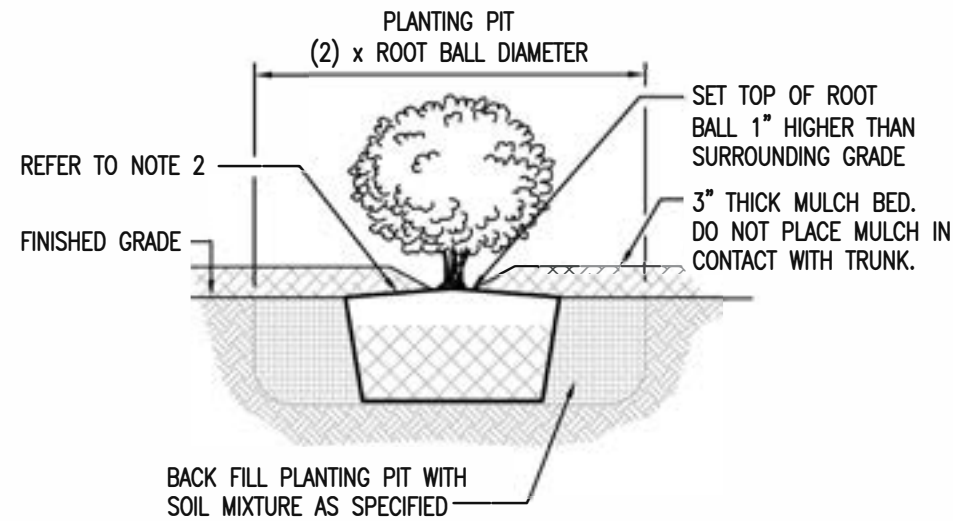
- c. Installation
- i. Only experienced installers who have completed similar landscaping work in type of material, design, and scale, shall be permitted to perform this work.
 - ii. Installer shall provide documentation showing five (5) recorded “successful” years of experience with similar work.
 - iii. Plant installation date(s) shall be coordinated a minimum of five (5) business days prior to planned date(s) for installation with campus Landscape Architect.
 - iv. Install all planting material per details shown in Figures 3F.07, 3F.08 and 3F.09

Figure 3F.07 Tree Planting



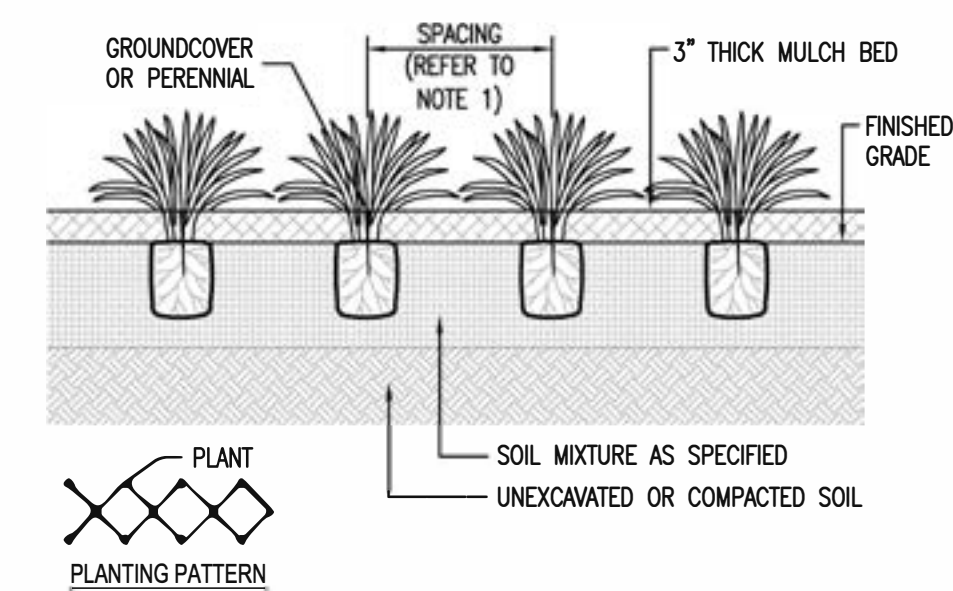
- d. Final Inspection and Acceptance
- i. Written request for final inspection and acceptance of the landscaping shall be submitted at least ten (10) days before the end of the warranty period.
 - ii. If any plant materials are determined unacceptable, another request from either the University and/or Contractor shall be made for inspection after the next growing season.

Figure 3F.08 Shrub Planting



- NOTE:
- 1. CONTRACTOR SHALL VERIFY THAT PLANTING PIT IS FREE DRAINING PER SPECIFICATION PRIOR TO PLANTING.
 - 2. REMOVE ALL BINDINGS AND BURLAP FROM THE TOP 1/3 OF ROOT BALL. PLACE ROOT BALL ON UNEXCAVATED OR COMPACTED SOIL.

Figure 3F.09 Groundcover and Perennial Planting



- NOTE:
- 1. PLANT IN DIAGONAL PLANTING PATTERN. REFER TO PLANT LIST FOR SPACING REQUIREMENTS.
 - 2. REFER TO PLANT LIST FOR GROUNDCOVER OR PERENNIAL TYPE.

F) SITE, CIVIL AND GROUNDS

k.1. UTILITIES: STORM DRAINAGE

- 1. General
 - a. ALL development on the Campus shall be provided with an adequate storm water management system that is approved and permitted to discharge into the City of Chicago’s storm water drainage system. This includes, but is not necessarily limited to, storm water inlets and catch basins, manholes, swales, storm sewers, detention basins, storm water quality best management practices (BMP), bioswales, rain gardens, etc.
- b. Locations
 - i. All Streets and Drives, Parking Lots, Building Entrances and Plazas, Outdoor Courtyards, Service areas, etc... shall be provided with storm water inlets, manholes, swales and piping properly spaced, sloped and sized to convey the designated storm frequency runoff to a positive outlet.
 - ii. Storm water drainage systems shall be designed utilizing gravity flow to their respective outlet. The use of storm water lift stations to convey runoff is discouraged and must be approved by Facilities Services prior to design.
 - iii. Areas designated for storm water detention shall be approved by Facilities Services prior to design. Due to the urban setting of this campus, it is encouraged that detention systems be placed below grade and the stored volume of water be considered for additional purposes, i.e. irrigation, other non-potable uses.
 - iv. Due to a relatively high water table in areas on campus, depth of detention areas may be limited; this must be an early design consideration. Campus sub-soils are generally porous and well draining, making them work well for infiltration and aquifer recharge.
 - v. Any dewatering / sump pump water collected shall be considered for sustainable re-use including but not limited to irrigation or sustainable building equipment uses.
 - vi. Separation between sewers and water lines shall be maintained as described by all State and Local codes and ordinances.

2. Design Standards

- a. Regulatory Requirements
 - i. All design, material and installation, whether within a right-of-way or easement, or not, shall meet the requirements of such local government or other agency having jurisdiction over storm drainage - City of Chicago Department of Water Management
 - ii. All designs shall incorporate an adequate “flood route” to convey storm water from blocked inlets or pipes, excessive rainfall intensities, and combinations thereof, away from buildings. In no case, shall water be able to pond on surfaces deeper than seven (7) inches.

3. Construction Standards

- a. Storm water Inlets, Catch Basins and Manholes
 - i. Precast concrete structures with gray iron castings load rated for the appropriate conditions.
 - ii. Install per City standards
- b. Storm water Piping
 - i. Reinforced concrete pipe with soil tight joints.
 - ii. Install per City standards
 - iii. All piping shall be provided with detectible warning tape with tone wire. Tone wire shall be properly terminated at each end and accessible adjacent to pipe intersections for ease of locating.
- c. Drainage Swales
 - i. All drainage swales with slopes less than 2% shall be provided with an underdrain system with positive discharge and have a planted drainage bed.
- d. Detention Systems
 - i. Unless approved by Facilities Services, all storm water detention storage will be provided underground
 - ii. Install per City standards
- e. Storm water Best Management Practices (BMP)
 - i. Unless approved by Facilities Services, best management practices (BMP) shall be structured swirl type units.

- ii. Install per City standards

- f. Bioswales and Rain Gardens
 - i. Unless approved by Facilities Services, bioswales and rain gardens shall be limited to courtyards and park area uses.
 - ii. Install per City standards

k.2. UTILITIES: SANITARY SEWERS

- 1. General
 - a. ALL new building construction shall be provided with an approved and permitted sanitary lateral/sewer that discharges into the City of Chicago’s sanitary sewer system.
- b. Locations
 - i. Sanitary laterals shall be located such that potential impacts from tree roots, heavy equipment and traffic or building foundations are not a concern.
 - ii. Separation between sewers and water lines shall be maintained as described by all State and Local codes and ordinances.
 - iii. Sanitary sewer systems shall be designed utilizing gravity flow to their respective outlet. The use of a sanitary lift station to convey runoff is discouraged and must be approved by Facilities Services prior to design.

2. Design Standards

- a. Regulatory Requirements
 - i. All design, material and installation, whether within a right-of-way or easement, or not, shall meet the requirements of such local government or other agency having jurisdiction over sanitary waste.
 - 1. City of Chicago Department of Water Management
 - 2. Illinois Department of Public Health
 - 3. Illinois Plumbing Code
 - 4. Ten States Standards for Wastewater Facilities
 - 5. Illinois Environmental Protection Agency (IEPA)

F) SITE, CIVIL AND GROUNDS

3. Construction Standards
- a. Sanitary Manholes
- i. Precast concrete structures with gray iron castings load rated for the appropriate case.

ii. Install per City standards
- b. Sanitary Piping
- i. Extra Strength Vitrified Clay Pipe (ESVCP),ASTM-C-700

ii. Ductile Iron Pipe (DIP), Class 52

iii. Cast Iron Pipe (CIP)

iv. Install per City standards

v. All piping shall be provided with detectible warning tape with tone wire. Tone wire shall be properly terminated at each end and accessible adjacent to pipe intersections for ease of locating.

k.3. UTILITIES: SITE ELECTRIC DISTRIBUTION

1. General
- a. The intent of this section is to describe the basic requirements for locating and routing site electric distribution systems throughout the campus. Utility services and systems that are under the jurisdiction of others, shall be installed as required by those jurisdictions.
- b. Coordination with other utility jurisdictions and Facilities Services is required prior to locating and routing the site electric distribution systems on the campus.
- c. Locations
- i. Site electric distribution shall be placed in right of ways, easements or other designated ways that will prevent interference with other construction components, plantings and trees.

ii. All above and below ground splice boxes, pull boxes, manholes, transformers, etc. shall be located in a manner that protects the device from any vehicle damage and is accessible at all times.

- iii. Do not locate electric wire ways immediately adjacent to communication or low voltage wire ways.

d. Design Standards

i. Regulatory Requirements

1. All design, material and installation, whether within a right-of-way or easement, or not, shall meet the requirements of such local government or other agency having jurisdiction over this utility service.

2. Wire ways to be buried a minimum of 30” below finished grade and shall be provided with detectible warning tape with tone wire. Tone wire shall be properly terminated at each end and accessible adjacent to intersections for ease of locating.

3. Construction Standards

- a. Wire Ways
- i. Conduit shall be used for all electric wire ways throughout the Campus.

ii. Concrete duct banks shall be used for all primary and emergency electric distribution unless directed otherwise by regulating jurisdiction or Facility Services.
- b. Splice boxes, Pull boxes and Manholes
- i. Precast concrete structures with gray iron castings load rated for the appropriate case. Size to be adequate for its function.

ii. Precast polymer concrete with lid load rated for the appropriate case. Size to be adequate for its function.

k.4. UTILITIES: SITE WATER DISTRIBUTION

1. General
- a. The intent of this section is to describe the basic requirements for locating and routing site water distribution systems throughout the campus. Utility services and systems that are under the jurisdiction of others, shall be installed as required by those jurisdictions.
- b. Coordination with other utility jurisdictions and Facilities Services is required prior to locating and routing the site water distribution systems on the campus.
- c. Locations
- i. Site water distribution shall be placed in right of ways, easements or other designated ways that will prevent interference with other construction components, plantings and trees.

ii. All fire hydrants and valves shall be located in a manner that protects the device from any vehicle damage and is accessible at all times. Coordinate device types with the local water utility jurisdiction and fire department.

iii. Locate water lines to provide required clearances from other below grade utilities and sewers.
2. Design Standards
- a. Regulatory Requirements
- i. All design, material and installation, whether within a right-of-way or easement, or not, shall meet the requirements of such local government or other agency having jurisdiction over this utility service.

City of Chicago Department of Water Management

Chicago Fire Department

Illinois Department of Public Health

Illinois Plumbing Code

Illinois Environmental Protection Agency (IEPA)
3. Construction Standards
- a. Water piping, valves, fittings, valve boxes, meters and hydrants to meet the requirements of the City of Chicago Department of Water Management.

F) SITE, CIVIL AND GROUNDS

I. DEMOLITION, SITE CLEARING AND

EROSION CONTROL

1. General

- a. The necessary site clearing and demolition for the project site shall be shown on a plan to indicate which elements are required to be removed, modified, relocated or salvaged and turned-over to Facilities Services.
- i. Existing site items to remain shall be protected to keep the item in their original state. (Photographing the item to remain before commencing work will be the basis of determining its original state.)
- ii. Items to be salvaged and stored by the University shall be inventoried, confirmed for viability of future use, documented in current state (via photo), and adequate storage space confirmed / coordinated with Facilities Services.
- b. All projects that have any earthwork activity shall be provided with a Storm Water Pollution Prevention Plan (SWP3) to define the appropriate use, maintenance and monitoring requirements for erosion and sediment control measures necessary for the site. These items include but are not necessarily limited to the following:
 - i. Silt Fencing
 - ii. Inlet protection
 - iii. Sediment basins
 - iv. Check dams
 - v. Concrete washout areas
- c. Refer to Performance Standards for locations of staging areas, stockpiles, storage of materials and contractor parking.

2. Design Standards

- a. Regulatory Requirements
 - i. All erosion and sediment control design, material and installation shall meet the requirements of such local government or other agency having jurisdiction.
 - 1. Illinois Environmental Protection Agency (IEPA)
 - 2. Illinois Department of Natural Resources Conservation Services (NCRS)
 - 3. City of Chicago

b. Monitoring

- i. Erosion and sediment control measures shall be continuously monitored throughout their use for functional adequacy and performance in addition to the required monitoring necessary after each rainfall event.

c. Vegetation Assessment and Protection

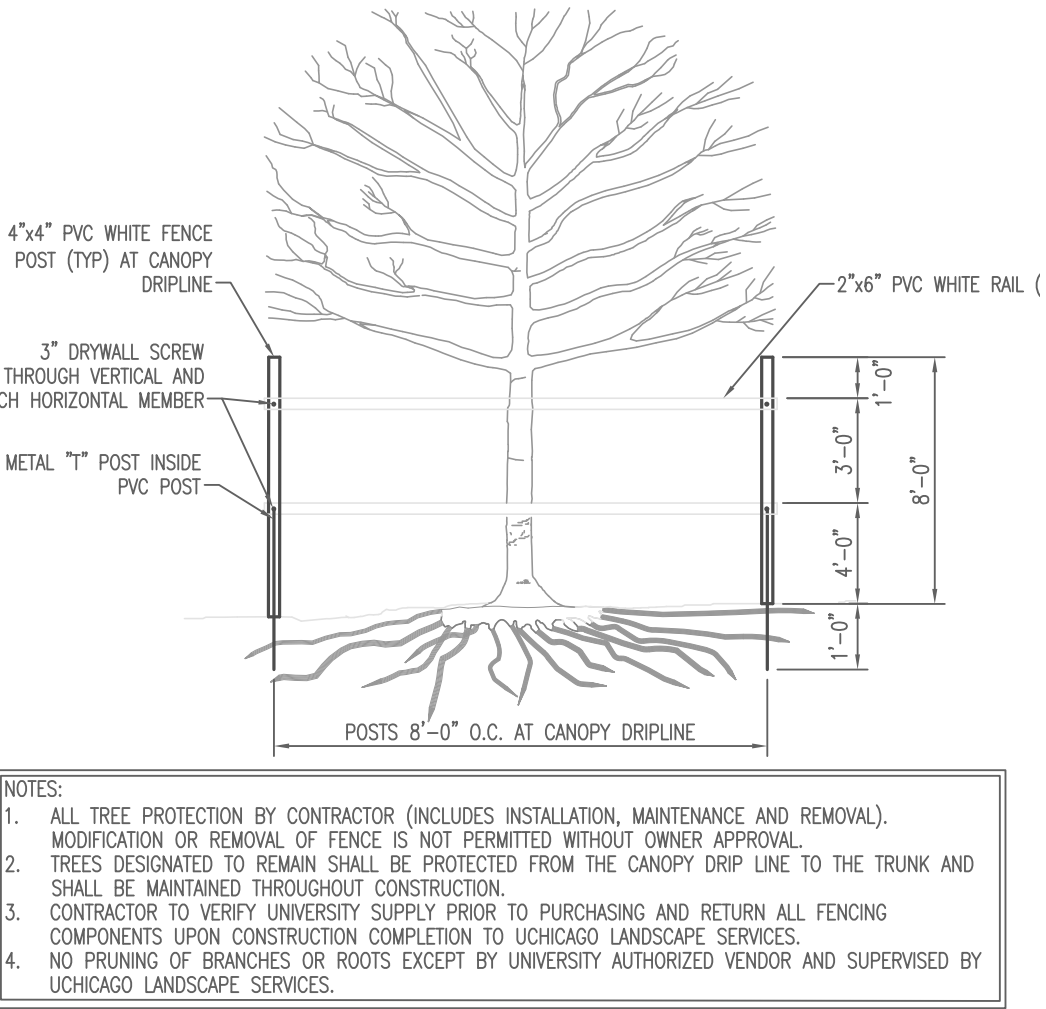
- i. **Tree Protection: Trees that are designated to remain shall be protected from the drip line to the trunk around the entire circumference of the tree and shall be maintained throughout construction.**
 - 1. Access within the tree protection zone shall be minimal and limited to tree maintenance / watering.
 - 2. The tree protection zone is designed to protect the tree from damage related to construction activity. The following include but are not limited to activities that are restricted in the tree protection zone:
 - a. Removal of branches, general pruning, or root pruning
 - b. Trenching for utilities or other construction related activity
 - c. Chaining/locking equipment to trees
 - d. Laydown space for construction materials
 - e. Spoils from site excavation/demolition/construction
 - f. General foot traffic

3. Refer to figure 3F.10

- ii. Tree Pruning and Root Pruning: Any construction activity proposed near or within any tree canopy / dripline shall be assessed to determine whether said tree(s) shall be pruned and / or root pruned prior to construction activity. Pruning and root pruning is seasonal so this consideration must be made very early in project design so the appropriate timing for said activity is not missed.
- iii. General Planting Protection: Careful assessment and delineation of construction zones and associated fencing shall consider protection of existing vegetation beyond trees including shrubs, grasses and perennials. Particular attention shall be paid to protection of established hedges, shrubs and grasses that will be difficult to replace.

3. Construction Standards

Figure 3F.10 Tree Protection



- a. Silt Fencing
 - i. Mirafi 140N or equal
- b. Inlet protection
 - i. Prefabricated devices
 - ii. Field built devices
- c. Tree Protection
 - i. Utilize UV resistant plastic snow fence and framed structure to protect trees.

F) SITE, CIVIL AND GROUNDS

m. EARTHWORK

- 1. General
 - a. All projects that have any earthwork activity shall be provided with a Storm Water Pollution Prevention Plan (SWP3) that defines the appropriate use, maintenance and monitoring requirements for erosion and sediment control measures necessary for the site.
 - b. Refer to General Design and Construction Standards for locations of staging areas, stockpiles, storage of materials and contractor parking.
 - c. Refer to the project Geo-Technical Report for design requirements related to earthwork activities which include the following:
 - i. Foundation bearing pressures
 - ii. Dewatering during and after construction
 - iii. Backfill material composition and placement
 - iv. Topsoil composition and placement
 - v. Soil Stabilization
 - vi. Testing and Inspection

2. Design Standards

- a. Regulatory Requirements
 - i. All earthwork activity shall meet the requirements of such local government or other agency having jurisdiction. , including but not limited to:
 - IEPA
 - Illinois NRCS
 - City of Chicago
 - OSHA
- b. Shoring and Support
 - i. Utilize acceptable means for shoring and supporting existing conditions surrounding excavations.
- c. Trenching and Excavation
 - i. Refer to OSHA Standards for excavation slopes and trench width restrictions.
 - ii. Provide necessary barricades and barriers to protect open excavations at all times.
 - iii. Minimize having open trenches for extended periods of time. It is encouraged that excavations for piping, footings, etc... are backfilled the same day. Routing and placement of underground components shall be taken into account during design.
- d. Temporary Drainage of Excavations
 - i. Provide positive drainage away from the tops of excavations by utilizing berms, swales and pipes in order to keep surface water from entering the excavation or trench.
 - ii. Utilize sump areas and pumps as necessary to keep bottoms of excavations dry. Refer to the Geo-Technical Report for additional dewatering measures that may need to be included.

3. References

City of Chicago- Department of Water Management
Stormwater Management Ordinance Manual-January 2011
Chapter 11-18 Stormwater Management of the Municipal Code of Chicago
Standard Details for Water main Installations- April 2009
2011 Regulations for Sewer Construction and Stormwater Management-January 2011

G) UTILITIES SYSTEMS

1. INTRODUCTION

The following Utility System Standards provide requirements and guidelines for use by the Consultant in the design and construction of the following campus-wide utility systems at the University:

- a. Utility Piping Identification
- b. Vaults for Campus Utilities
- c. Chilled Water
- d. High /Medium Pressure Steam and Condensate
- e. Compressed Air

This section shall apply to the campus-wide utility systems listed above from their point of origin or existing connection to their entrance to buildings, including wall penetration and up to and including the first shut-off valve inside the building. Steam utility shall include metering and the first PRV up to and including safety relief valve; condensate utility shall include the main building condensate receiver/pump, metering and drainage piping. Chilled water utility shall include metering, chilled water bridge and heat exchanger (if applicable). Specific component requirements for flash tanks, high pressure drips, condensate receivers, etc. shall comply with provisions of the Mechanical section of these Standards. The Campus Utility system components located inside new buildings may be included in the building bid/construction package, subject to approval by the University.

Campus natural gas system additions and modifications shall be designed to comply with the rules and regulations of Peoples Gas utility company.

The campus utility piping systems may be installed in tunnels and vaults or be direct-buried. The type of installation shall be determined upon consideration of all major factors and anticipated schedule for preventive maintenance and replacement of major system components; the final determination shall be made in consultation with the University. The factors that shall be considered:

- Reliability of service, time back in service after a failure
- Durability and life expectancy
- Serviceability, preventive maintenance
- Site limitations and surface improvements
- Life-cycle cost
- First cost

2. SYSTEM GUIDELINES

The following major design criteria (including Table 3G.01) shall be used in implementation of these standards:
a. **Utility Piping Identification:** Provide piping labels to match existing. Comply with ASME piping identification standards.

- b. **Vaults for Campus Utilities:** Each vault shall be equipped with:
- Access door H1W (single leaf) and H2W (double leaf) equipped with T-316 stainless steel slam lock as manufactured by Holiday Products Inc. of Orlando, Florida and a Model T key lock with removable key in LEVEL-LOCK cover. Access door frame and cover shall be rated for IDOT H-20 load.
 - University standard ladder
 - Adequate vent holes
 - Locally-switched lighting; switch shall be reachable from ladder
 - Service receptacle
 - Sump pump
 - All conduits shall be mounted high above floor and kept away from access openings. Top of a vault shall be elevated with respect to the adjacent final grading.

Table 3G.01 Chilled Water, Steam and Condensate, & Compressed Air Guidelines

Utility	Type / Location	Operating Temperature	Operating Pressure	Notes
c) Chilled Water	Supply	45 +/-5 Degrees F	150 psig maximum	Design Temperature Differential: 16 Degrees F (Preferred) 12 Degrees F (Minimum)
	Return	57 +/-5 Degrees F	150 psig maximum	
d) Steam and Condensate	Main and Southwest Campus Distribution	460 Degrees F	175 psig	Campus South operating pressure is 80 psig
	Medical Center Distribution	380 Degrees F	125 psig	
	Main Quads, North Campus, Woodlawn Distribution	355 Degrees F	80 psig	
	Medium Pressure (smaller buildings east of University Ave.)	260 Degrees F	20 psig	
e) Compressed Air	North Campus	-	80 psig	
	Main Quads / South Campus	-	50 psig	

G) UTILITIES SYSTEMS

3. COMPONENT MATRIX & GUIDELINES

The following criteria (Table 3G.02) shall be used in implementation of these guidelines:

Table 3G.02 Component Matrix & Guidelines

System	Installation	Piping	Valves	Testing	Insulation	Excavation / Backfill
Chilled Water	Direct Buried	PS-3	VS-3	TCS-1	NONE	Site, Civil and Grounds*
	Tunnel / Vaults	PS-4	VS-2	TCS-1	IS-2	N/A
Steam	Direct Buried	PS-1	NONE	TC-3, CS-4	PS-1	Site, Civil and Grounds*
	Tunnel / Vaults	PS-2	VS-1	TC-3, CS-4	IS-1	N/A
Condensate Return	Direct Buried	PS-1	NONE	TC-3, CS-4	PS-1	Site, Civil and Grounds*
	Tunnel / Vaults	PS-2	VS-1	TC-3, CS-4	IS-1	N/A
Compressed Air	Direct Buried	CAS-1	NONE	TC-2, CS-2	NONE	Site, Civil and Grounds*
	Tunnel / Vaults	CAS-1	CAS-1	TC-2, CS-2	NONE	N/A
* Provide a formal submittal (excavation request) that defines applicable excavation, trenching, dewatering, backfill and compaction requirements with each utility project.						

- a. PS-1 Direct Buried Steam and Condensate Piping
 - 1. Application: Distribution of campus steam, condensate and high pressure steam drip return.
 - 2. Manufacturers:
 - a. Perma-Pipe 500 modified to University requirements stated herein.
 - b. Rovanco 800 modified to University requirements stated herein.
 - c. Thermacor modified to University requirements stated herein.
 - 3. Carbon steel seamless carrier pipe:
 - a. Steam: extra strong; piping components shall meet 300 psig rating.
 - b. Pumped condensate: extra strong; piping components shall meet 150 psig rating.
 - c. High pressure drip return: double extra strong; piping components shall meet 300 psig rating.
 - d. Fittings: seamless steel, material and wall thickness to match adjoining piping.
 - e. Joints: butt or socket welded.
 - f. Pitched in the direction of steam flow, when possible.
 - g. Take-off from existing pipe: by Weldolet or Sockolet, up to 50% of main pipe; take-off with tee if 50% of main pipe or greater.
 - 4. Insulation: Pre-molded perlite blocks (each block not to exceed 2 inch thick with joints overlapped) and continuously wrapped within an intermediate casing made of sheet metal and strapped with metal clamps; acceptable sheet metal are matching galvanized steel, aluminum or stainless steel. Apply mastic between all perlite joints. Provide adequate insulation thickness so that intermediate casing temperature to be less than 207 Degrees F.
 - 5. Intermediate casing: Carbon steel 10-gauge thick with spacers separating inner pipe from intermediate casing. Provide passive cathodic protection with buried magnesium anodes; provide isolation flanges to segregate building systems from buried piping.

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

G) UTILITIES SYSTEMS

- 6. Outer jacket: Casing shall be covered with foam insulation and smooth-bore without seam mark polyethylene jacket 175 mil thick. Insulation thickness (1.5 inch minimum, 4 inch maximum) shall be economically justified. Outer jacket temperature shall be less than 100F.
- 7. Field joints: Meet same standard as the above. Outer joint shall be heat applied polyethylene shrink wrap.
- 8. Piping flexibility analysis: Piping shall be design to meet ASME B31.1 requirements, utilize cold springing as applicable; pre-stressed design is not allowed. Submit for University review.
- 9. Expansion compensation:
 - a. Preferred method: pipe loops
 - b. Acceptable method: expansion joints, inside stem vault only.
 - c. Install anchors in vault only, anchors on direct-buried piping are not allowed.
- 10. Piping entering concrete vault or basement: Adequately sized, sleeved penetration shall be provided to allow the installation of link seal to the outer jacket. Link seal shall be serviceable from inside. Fill the exterior of the opening with Bentonite plug; provide 2 inch Bentonite hydro-grout seal. Sheet-wrap casement pipe exterior and terminate it on wall with cold tar seal.
- 11. Quality assurance: After installation and prior to system startup, open the drain valves at each vault and remove any water inside the jacketing. Blow dry compressed air into the jacket while venting the other end to remove any moisture that may have been trapped inside the jacket during construction.

- b. PS-2 Steam and Condensate Piping in Tunnels/Vaults
 - 1. Application: Distribution of campus steam, condensate and high pressure steam drip return.
 - 2. Carbon steel seamless pipe:
 - a. Steam: extra strong weight piping pressure shall meet 300 psig rating.
 - b. Pumped condensate: extra strong; piping pressure shall meet 300 psig rating.
 - c. High pressure drip return: double extra strong; piping pressure shall meet 300 psig rating.
 - d. Fittings: seamless steel, material and wall thickness to match adjoining piping, pressure ratings: 300 psi over 2 inch, 800 psi for 1 to 1 ½ inch and 2000 psi for 1 inch or less pipe diameter.
 - e. Joints: 2-1/2“ and larger butt welded, 300 psi rating; 2” and smaller socket welded, 2000 psi rating.
 - f. Take-off from existing pipe: by Weldolet or Sockolet when diameter of branch pipe is lesser than 50% of that of main, pressure rating to match joints.
 - g. Flanged connections: at valves and expansion joints only.
 - h. Flange bolts: SAE Grade 8 or ASTM A193 B7 bolts with 2H nuts.
 - 3. Piping flexibility and safety analysis:
 - a. Steam and condensate piping shall be design to meet ASME B31.1 requirement.
 - b. Indicate displacements, forces and moments at each pipe hanger and support location.
 - c. Determine bending moments for flange bolts torque calculations.
 - d. Provide steam safety relief calculations.
 - e. Utilize cold springing as applicable; pre-stressed design is not allowed.
 - f. Submit calculations to the University for review.

- 4. Expansion compensation:
 - a. Preferred method: pipe loops
 - b. Acceptable method: expansion joints may be proposed to the University if pipe loops are not feasible.

G) UTILITIES SYSTEMS

- 5. Hangers and supports: Installation is to be in accordance with mechanical provisions of the standards. All supports shall be floor- or wall-mounted, hanging from tunnel or vault roof is not allowed. Provide design for piping supports and attachments to building structures. Submit design and calculations to the University for review.
- 6. Inside the concrete vaults or basement:
 - a. Provide factory designed cover plate to cover the end between the pipe and outer jacket.
 - b. Provide 1 inch warm up bypass line with steel gate valve rated at 2000 psi at 400 Degrees F. at the building main isolation valve.
 - c. Provide a ball valve at the ¾ inch drain connection.
 - d. Provide a pipe connected to the ¾ inch vent connection; run it toward to the top of the vault or basement and terminate with a gooseneck.
 - e. Provide steam trap assembly to drain condensate from both sides of the isolation valve.
 - f. Provide Spence PRV for sizes 4” and under. Use Fisher PRV for 6” and larger. Self- regulating SRV, drip pan elbow. Provide PRV and SRV sizing and calculations for review.
 - g. Provide steam and condensate metering at the first PRV.
 - h. Provide the main building condensate receiver/pump, metering and drainage piping.
- 7. Quality assurance: After installation and prior to system startup, open the drain valves at each vault and remove any water inside the jacketing. Blow dry compressed air into the jacket while venting the other end to remove any moisture that may have been trapped inside the jacket during construction.

- c. **PS-3 Direct Buried Chilled Water Piping**
 - 1. Application: Distribution of campus chilled water.
 - 2. High Density Polyethylene (HDPE) pipe:
 - a. Minimum pressure rating: 160 psig
 - b. Carrier pipe: SDR-11 min.
 - c. Fittings: SDR-9 min.
 - d. Joints: butt fusion welded with fusion machine. Electro-fusion welding can be proposed in lieu of fusion if use of fusion machine is not feasible; prior approval from University is required.
 - e. Take-off from existing pipe: construction and ratings to match joints
 - f. Flanged connections: at valves only
 - 3. Minimum depth of top of piping shall be 5 feet below final surface grade. Slope piping upwards toward building, provide air vents at all high points. Generally, maximum depth of bottom of piping shall not exceed 12 feet.
 - 4. Direct-buried chilled water piping shall not require any insulation.
- d. **PS-4 Chilled Water Piping in Tunnels/Vaults**
 - 1. Application: Distribution of campus chilled water system, other than direct buried.
 - 2. Carbon steel seamless pipe:
 - a. Standard weight piping, pressure shall meet 300 psig rating.
 - b. Fittings: seamless steel, material and wall thickness to match adjoining piping, pressure ratings 300 psi
 - c. Joints: 2-1/2 “and larger butt welded, 300 psi rating; 2” and smaller screwed or socket welded, 300 psi rating.
 - d. Take-off from existing pipe: by Weldolet or Sockolet when diameter of branch pipe is lesser than 50% of that of main, pressure rating to match joints.
 - e. Flanged connections: at valves and expansion joints only.

- 3. Piping flexibility analysis:
 - a. Chilled water piping shall be design to meet ASME B31.1 requirement.
 - b. Indicate displacements, forces and moments at each pipe hanger and support location.
 - c. Determine bending moments for flange bolts torque calculations.
 - d. Submit calculations to the University for review.
- 4. Expansion compensation:
 - a. Preferred method: pipe loops
 - b. Acceptable method: expansion joints, subject to approval by the University.
- 5. Hangers and supports: Installation is to be in accordance with mechanical provisions of the standards. All supports shall be floor- or wall-mounted, hanging from tunnel or vault roof is not allowed. Provide design for piping supports and attachments to building structures. Submit design and calculations to the University for review.
- 6. Inside the concrete vaults or basement:
 - a. Provide a ball valve at the 3 inch drain connection.
 - b. Provide a pipe connected to the 1 inch vent connection; run it toward to the top of the vault or basement and terminate with a gooseneck.
- 7. Quality assurance: After installation and prior to system startup, open the drain valves at each vault and remove any water.
- e. **CAS-1 Compressed Air System**
 - 1. Application: Distribution of campus compressed air.
 - 2. Carrier pipe:
 - a. Tunnel piping: Type K copper with brazed joints 3 inches and smaller. Galvanized steel 4 inches and larger.
 - b. Underground direct burial piping: Polyethylene SDR-11, 150 psig Asahi/America TUB 124 blue pipe or approved equivalent (rated for gas service).

G) UTILITIES SYSTEMS

- c. At each building or group of buildings: Type K refrigeration grade copper with brazed joints and end caps and line size isolation ball valve, 1 inch minimum.
- d. Piping inside steam vaults shall be insulated and jacketed.
- 3. Isolation, drain and vent valves: Ball valves, 4" and Smaller: MSS SP-110, Class 150, 600-psi CWP, ASTM B 584 bronze body and bonnet, 2-piece construction; chrome-plated brass ball, standard port for 1/2-inch valves and smaller and conventional port for 3/4-inch valves and larger; blowout proof; bronze or brass stem; Teflon seats and seals; threaded or brazed connections. Distribution system isolation valves shall be placed in shallow manholes.
 - Operator: Steel handwheel for isolation valves and ¼ turn lever for drain and vent valves.
 - Stem Extension: For valves installed in insulated piping.
 - Memory Stop: For operator handles.
- 4. Piping specialties:
 - a. Flow meter: with totalizer for local reading and remote campus BAS data collection.
 - b. Pressure regulator: cast iron body, stainless steel trim; specify connection size and outlet pressure range, Fisher Pressure Reducing Regulator or approved equivalent.
 - c. Filtration at building entrance: line size; metal housing rated for 250 psig service; differential pressure gauge; adjustable timer blow-down;
 - i. Upstream Particulate filter: 5 micron element
 - ii. Downstream Coalescing filter: .01 micron element
 - iii. Provide isolation valves upstream and downstream of filter train
 - iv. Provide by-pass line with ball valve.
 - v. Acceptable manufacturers: Balston or Arrow Pneumatics High Flow Model
- 5. Hangers and supports: Installation is to be in accordance with mechanical provisions of the standards. Each hanger or support rod shall be fitted with a double nut and a washer.

f. VS-1 Valves for Steam and Condensate Piping in Tunnels / Vaults**1. Gate valve:**

- a. 2" or larger diameter. Bonny Forge ASME Class 300 (500 psi pressure rating at 400 Deg. F) flanged valve with cast steel body, bolted bonnet, Stellite seat ring, 13% Chromium steel wedge, spiral SS graphite gasket, steel bearing, ductile iron hand wheel; valve 2 inch to 6 inch shall be stem-mounted hand wheel operated; valves 8 inch and above shall be hand wheel gear operated with position indicator.
- b. 1-1/2" or smaller diameter. Bonny Forge ASME Class 800 (2000 psi pressure rating at 400 Deg. F) socket welded valve with forged steel body, bolted bonnet, Stellite seat ring, 13% Chromium steel wedge, steel bearing, ductile iron stem-mounted hand wheel with position indicator.
- c. Main isolation valve shall be provided on Steam and Condensate lines inside each building within 5 feet from entering the building and at each take-off from mains. 1" diameter warm-up bypass with a gate valve shall be provided at both sides of each isolation valve.

2. Butterfly valve: Flanged butterfly valve is allowed only when insufficient space exists for a gate valve 3 inches or larger diameter. Adams MAK triple-offset, ASME Class 300 (500 psi pressure rating at 400 Deg. F) valve with cast steel body and hand wheel, bidirectional metal-to-metal zero-leakage seal. Install valves to match direction of pressure.

3. Flange gaskets: Provide Flexitallic Thermiculite stainless steel with inner and outer rings.

4. Steam trap assembly:

- a. Armstrong trap, cast steel body
- b. Provide trap on both sides of steam isolation valve
- c. For each trap at any vertical drop of a steam pipe, provide a full size dirt leg with bottom blow down and a gate valve; take-off to trap assembly shall be at least 6" above the bottom of dirt leg
- d. Provide test port downstream each steam trap

e. Provide union on each side of steam trap to facilitate its removal

f. Provide high pressure piped drip inside each vault

5. Bolts and nuts: ASTM A193 B7 or SAE Grade 8 bolts with 2H nuts. Provide double-nuts, torque to the applicable ASTM standard requirement, and re-tighten after start-up.

g. VS-2 Valves for Chilled Water Piping in Tunnels/Vaults**1. Manual valve:**

- a. Isolation Valves. Bray valve series 31H with cast iron body, 416 s.stl. stem, nylon coated ductile iron disc; EPDM seat; class 125/150 bolt pattern; lug connection; 250 psi bubble tight shut off and dead end service; valve 2 inch to 6 inch shall be lever operated; valves 8 inch and above shall be hand wheel gear operated; position indicator. Main isolation valve shall be provided on Chilled Water Supply and Chilled Water Return lines inside each building within 5 feet from entering the building.
- b. Drain and vent valves. Ball valves, 2-1/2" and Smaller: MSS SP-110, Class 150, 600-psi CWP, ASTM B 584 bronze body and bonnet, 2-piece construction; chrome-plated brass ball, standard port for 1/2-inch valves and smaller and conventional port for 3/4-inch valves and larger; blowout proof; bronze or brass stem; Teflon seats and seals; threaded connections.

• Operator: Steel handwheel.

• Stem Extension: For valves installed in insulated piping.

• Memory Stop: For operator handles.

2. Automated valve: Bray series 31; 250 psi shut off, EPDM seat; actuator Bray series 92/93 rack and pinion pneumatic actuator with hand wheel; size for 50 psi air; with Bray series 05 de-clutchable manual over ride; Bray series 6A E/P positioner with position indicator; all other items same as manual valve above.

Limit switch for remote status or control: Bray model 50.

G) UTILITIES SYSTEMS

h. VS-3 Valves for Direct Buried Chilled Water Piping

1. Manual valve: Pratt valve series HP-250II with ANSI B16.1, Class 250 ductile iron body, ASTM A-564 Type 630 condition H-1150 shaft extended to grade level, nylon coated ductile iron disc; EPDM seat; class 125/150 bolt pattern; flanged connection; 250 psi bubble tight shut off and dead end service; Manual actuators shall be of the traveling nut, self-locking type and shall be designed to hold the valve in any intermediate position between fully open and fully closed without fluttering or creeping. The actuator shall have mechanical stops that will withstand and input torque of 450 ft/lb. against each stop. Manual isolation valve shall be provided on Chilled Water Supply and Chilled Water Return lines outside of each building within 5 feet from entering the building, at each street crossing and at each take-off from mains. Terminate the shaft extension in a manhole buffalo box with cover to protect the shaft from ground traffic.
2. Air Vent valve: Apollo flanged ball valve in a manhole buffalo box with cover at grade to protect the shaft from ground traffic. Vent piping shall be HDPE, fusion welded and flanged at connection to ball valves.
3. Companion flange: Provide ductile iron extensions to each side of valve, bolt to HDPE pipe flange with stainless steel bolts and nuts, applicable gasket.

i-1.TCS-1 Chilled Water Piping Testing and Flushing Guideline (Campus chilled water distribution direct-buried pipes (HDPE)):

1. Hydro testing prior to backfill:
 - a. Fill piping with water and slowly increasing pressure and hold steady at 50 psi increments to allow stretching of piping material and weather influence.
 - b. All joints shall be exposed all around and trench shall be dry so that joints can be inspected for leak.
 - c. Pressure shall be maintained steady at 220 psig for 4 hours with no leak at the joints.

- d. Pressure shall be brought down to 160 psig and left over night. All joints shall be checked for leak the next morning.
 - e. Valves shall be closed one at the time and kept under steady pressure of 160 psig for 1 hour with no leak.
 - f. If there is no leak, lower the pressure to 50 psig. Re-torque bolts at valve flanges.
 - g. Backfill pipes with 50 psig fill pressure; do not backfill otherwise.
 - h. Record test.
2. Hydro testing after backfill:
- a. At the end of the project, fill piping and slowly increasing pressure and hold steady at 50 psi increments.
 - b. Increase pressure to 220 psig and maintain steady for 4 hours.
 - c. Record test. This report shall be submitted to the University Mechanical Engineer before system startup. This report shall be part of the commissioning document.
3. Flushing and cleaning:
- a. Pipes stored at construction site shall have ends covered.
 - b. Do not connect new pipe to existing until the flushing and cleaning has been completed.
 - c. During the fusion process and after facing of pipe joint, pipes shall be separated to have all “shaving ribbons” removed.
 - d. After installation pipes shall be filled with water and flushed.
 - e. Ends of supply and return pipes shall be connected after testing and flashing has been completed.
 - f. Circulate water at 5 to 8 fps until no debris is caught at 5 micron strainer for 24 hours. Provide flushing machine with adequately sized pump to provide the flow required to reach stated velocities.
 - g. Record test.

- i-2.TCS-1 Chilled Water Piping Testing and Flushing Guideline (Campus chilled water distribution piping in tunnels and vaults (steel)):
1. Hydro testing:
 - a. Prior to backfill of adjacent direct-buried piping, fill piping with water and slowly increasing pressure and hold steady at 50 psi increments.
 - b. Pressure shall be maintained steady at 225 for 4 hours with no leak at the joints.
 - c. If there is no leak, lower the pressure to 50 psig. Re-torque bolts at valve flanges.
 - d. Re-test together with the adjacent direct-buried piping.
 - e. Record both tests. These reports shall be submitted to the University Mechanical Engineer before system startup. These reports shall be part of the commissioning document.
 2. Flushing and cleaning:
 - a. Piping segments in vaults shall be flushed and cleaned following the procedure for flushing and cleaning of the adjacent direct-buried pipe.
 - b. Cleaning procedure for mains in tunnels shall be developed by a Consultant specific to each project and approved by the University.

G) UTILITIES SYSTEMS

j. TS-2 Pressure Test for Compressed Air Piping

1. General:

- a. Piping system shall first be assembled and erected, then pressure tested and finally blow- out and cleaned.
- b. Lines open to atmosphere such as safety relief lines and lines downstream of the last shutoff valve need not be tested. These lines shall be visually inspected to determine that all joints are installed properly.
- c. Pressure vessels and other equipment built and tested to codes and specifications need not be tested.
- d. If local or others codes and regulations are more stringent, they shall take precedent.

2. Preparation for testing:

- a. At the time of testing, pipe metal temperature shall not be below 40F.
- b. All pipe joints shall be visually inspected for proper installation.
- c. All flanged, threaded and welded joints shall be left unpainted and un-insulated.
- d. Pumps, compressors, heat exchangers, safety valves, flame arrestors, vessels, rupture disks, self-contained regulators and any other equipment shall not be subjected to the piping test pressure. The equipment shall be bypassed or disconnected, and pipe ends blind flanged or removed and a spool piece inserted in its place.
- e. When it is necessary, for practicality, to include a vessel or other equipment, the test pressure shall not exceed the allowable cold limit of the equipment. Prior approval must be obtained from the University Mechanical Engineer.
- f. Piping connected to other lines (existing lines or lines installed by others) shall be isolated or blanked off for testing.
- g. Instrumentation piping shall be tested together with the piping system up to the block valve nearest to the instrument. All instruments shall be excluded from the test by either disconnecting the piping at the instrument and capping the pipe or closing the blocking valve nearest the instrument.

- h. Automatic control valve shall be in the open position unless provided with a by-pass permitting application of pressure to both sides.
- i. Expansion joints shall be provided with temporary restraints if required for the additional pressure load under test, or they shall be isolated during the pressure test.
- j. One or more calibrated indicating test gauges shall be installed in the piping to coordinate the pressuring operation.

3. Test procedure:

- a. The gas used as the test medium shall be clean, dry, oil-free air or nitrogen. Prior approval must be obtained from the University Mechanical Engineer if an alternate test gas is to be used. Alternate test gas must be nonflammable, nontoxic and harmless to the piping material in the system.
- b. Initially piping pressure shall be brought to 25 psig. If no leak is found, the pressure shall be slowly increased in increments of 25 psig with 10 minutes allowed at the end of each increment for equalization, until the test pressure is reached.
- c. The test pressure shall be held for 4 hours continuously. Include additional time to examine pipe joints and connections for leakage.
- d. Piping systems shall be tested to 150 psig or 1.5 times operating pressure, whichever is greater.
- e. A soap solution shall be applied to all joints undergoing pneumatic pressure testing.
- f. Leaks shall be marked and identified for repair. Major repairs or additions to the piping system shall be retested. Minor repairs may be waived with the permission of the University Mechanical Engineer. Repairs shall be inspected and observed for leaks.
- g. System isolation valves shall also be tested for leaks.
- h. Pressured shall be released gradually and discharged to a safe location upon completion of the test. Systems shall be returned to their pretest condition. All items previously removed, blocked off or disassembled shall be

reinstalled, reassembled and made operative.

4. Test Report:

- a. Fill out a test report. This report shall be submitted to the University Mechanical Engineer before system startup. This report shall be part of the commissioning document.

G) UTILITIES SYSTEMS**k. TS-3 Testing of Steam and Condensate Piping****1. General:**

- a. Steam piping testing includes steam and condensate.
- b. Piping system shall first be assembled and erected, and then pressure-tested and finally blow-out and cleaned.
- c. Do not install insulation to piping until testing is complete. Otherwise insulation shall be removed for testing at the contractor's expense.
- d. Lines open to atmosphere such as safety relief lines and lines downstream of the last shutoff valve need not be tested. These lines shall be visually inspected to determine that all joints are installed properly.
- e. Pressure vessels and other equipment built and tested to codes and specifications need not be tested.
- f. If local or others codes and regulations are more stringent, they shall take precedent.

2. Preparation for testing:

- a. At the time of testing, pipe metal temperature shall not be below 40F.
- b. All pipe joints shall be visually inspected for proper installation.
- c. All piping systems shall be checked for adequate vent and drain connections.
- d. All flanged, threaded and welded joints shall be left unpainted and un-insulated.
- e. Heat exchangers, safety valves, flame arrestors, vessels, rupture disks, self-contained regulators and any other equipment shall not be subjected to the piping test pressure. The equipment shall be bypassed or disconnected, and pipe ends blind flanged or removed and a spool piece inserted in its place.
- f. When it is necessary, for practicality, to include a vessel or other equipment, the test pressure shall not exceed the allowable cold limit of the equipment. Prior approval must be obtained from the University Mechanical Engineer.

- g. Piping connected to other lines (existing lines or lines installed by others) shall be isolated or blanked off for testing.
- h. All restrictions, such as flow nozzles and orifice plates, which interfere with filling, venting or draining shall be removed from the piping.
- i. Instrumentation piping shall be tested together with the piping system up to the block valve nearest to the instrument. All instruments shall be excluded from the test by either disconnecting the piping at the instrument and capping the pipe or closing the blocking valve nearest the instrument.
- j. Piping systems designed for steam shall be provided with additional temporary supports if necessary to support the weight of the test liquid.
- k. Spring hanger pipe supports shall have travel stops inserted.
- l. Automatic control valve shall be in the open position unless provided with a by-pass permitting application of pressure to both sides.
- m. Expansion joints shall be provided with temporary restraints if required for the additional pressure load under test, or they shall be isolated during the pressure test.
- n. Piping systems subject to extended hydrostatic test periods shall be provided with a protected device to relieve excess pressure due to thermal expansion.
- o. One or more calibrated indicating test gauges shall be installed in the piping to coordinate the pressuring operation. The location for test pressure gauges is at the bottom of the system for liquid service and at the top of the system for steam service. When test gauges are installed at the top of a system, care shall be taken to ensure that over pressuring of the piping and piping components does not occur at the bottom of the system due to the additional pressure imposed by the static head of the test media.

3. Test procedure:

- a. Test fluid shall be clean water. A suitable filter shall be provided at the fill line if sand, rust or other particles are present at the test water.
- b. Another suitable fluid may be used if there is possibility of freezing.
- c. Compressible fluid such as gas or air shall not be used.
- d. Piping system shall be slowly filled with test fluid. All vents and other connections which serve as vent shall be open during filling, so that all air is vented prior to applying pressure.
- e. Before test pressure is applied the piping must be allowed to assume approximately the same temperature as the test fluid.
- f. Test pressure shall be 400 psig for 175 psig/125 psig/80 psig steam and high pressure condensate drip return, except for 80 psig-rated steam piping located North of Midway street where the test pressure shall be 300 psig.
- g. Valves shall be closed one at the time and kept under steady pressure of 300 psig for 1 hour with no leak.
- h. Hydrostatic test pressure shall be 225 psig for all pumped condensate piping.
- i. Hydrostatic test pressure shall be maintained steady for 4 hours with no noticeable loss in pressure for a sufficient length of time to visually inspect all joints for leaks, but not less than four hours.
- j. There shall be no evidence of weeping or leaking.
- k. Leaks shall be marked and identified for repair. Major repairs or additions to the piping system shall be retested. Minor repairs may be waived with the permission of the University Project manager. Repairs shall be inspected and observed for leaks.
- l. System isolation valves shall also be tested for leaks.
- m. Upon completion of the test, systems shall be drained and returned to their pretest condition. All items removed, blocked-off or disassembled shall be reinstalled, reassembled and made operative as required.

G) UTILITIES SYSTEMS

4. All campus steam and condensate distribution piping shall require radiographic testing of the welds. Other piping to be tested shall be defined by the project requirements.

The piping contractor that performs the pipe welding shall provide the quality of weld to pass such inspection and include all preparation work for testing. The contractor will hire the testing agency to inspect 20% of the welds. Welds to be tested shall be chosen by the University assisted by the consulting engineer. Acceptance criteria for the radiographic test shall be per ASME B 31.1 paragraph 136.4.5. If there are any failed welds identified in the first 20%, another 20 % sample will be taken. If another failure is found in the 20% sample, testing of all welds will be required. The piping contractor pays for the testing of welds and all work to repair the welds.

5. Test Report: Fill out a test report. This report shall be submitted to the University Project Manager before system startup. This report shall be part of the commissioning document.

1. CS-2 Gas Piping Blow-out and Cleaning

1. General:

- a. Piping system shall first be assembled and erected, then pressure tested and finally blow- out and cleaned.
- b. Do not install insulation to refrigerant and ammonia piping until testing is complete.

2. Preparation for Blow-out:

- a. All pipe joints and tap-ins shall be visually inspected for proper installation and continuity.
- b. All welds in the carbon steel portion of the pipe system shall be hammered prior to the blow-out operation.
- c. Provide temporary connections to compressed air for blow-out.
- d. Equipment that has restricted flow passages or inaccessible areas where scale or particles could collect shall be by-passed or removed and replaced by a spool piece.
- e. All instrument lines shall be disconnected during and blow-out and cleaning operations and reconnected at the end of the operations.
- f. All low points and dirt legs shall have temporary blow-off valves.

3. Blow-out procedure:

- a. Piping system shall be blown through with oil-free compressed air at high velocity to remove all foreign matter.
- b. Care shall be taken such that the stream of air leaving the (temporary) discharge point dissipates harmlessly. Sign must be posted and personnel warned at the discharge area.
- c. Upon completion of blow-out operation, all temporary hoses, fittings and auxiliaries items shall be removed from the piping system.
- d. Piping system shall be returned to the pre-blow-out condition.

4. Piping cleaning procedure:

- a. After piping blow-out, clean system with a detergent solution.

- b. Recalculate the solution through the system for at least two hours.
- c. If recirculation is not possible, fill the system completely with hot detergent solution and allow fifteen minutes of contact time. Drain and replace with fresh solution. Repeat this procedure for eight times.
- d. Flush the system continuously for one hour with fresh water. Each use point shall be flushed thoroughly.
- e. Test the water used for flushing for phosphate concentration, conductivity and pH.
- f. Test the flush water from each point of use for concentration, conductivity and pH.
- g. When readings of the flush water and the incoming water for flushing are the same, drain the system.
- h. Blowout the system with oil-free compressed air. Purge from all outlets in the system.
- i. Upon completion, all temporary hoses, fittings and auxiliaries shall be removed from the system piping.
- j. Equipment and piping shall be returned to the pre-cleaning condition.

G) UTILITIES SYSTEMS

m. CS-4 Steam and Condensate Piping Flushing and Cleaning

- 1. General:
 - a. Piping system shall first be assembled and erected, and then pressure tested and finally flushed and cleaned.
 - b. Do not install insulation to the piping until testing is complete.
- 2. Preparation for flushing and cleaning:
 - a. Piping system shall be visually inspected for proper installation and continuity.
 - b. All welds in the carbon steel piping shall be hammered.
 - c. Equipment that has restricted flow passage or areas where sediment could collect shall either be bypassed or removed and replaced by a spool piece.
 - d. All instrument lines shall be disconnected during blowout and cleaning operations and reconnected at the end of the operations.
 - e. All low points and dirt legs shall have temporary blow-off valves.
- 3. Flushing procedure:
 - a. Flush through with clean fresh water to assure complete removal of all foreign matter.
 - b. Temporary discharge point of the line shall be in a safe location and discharge stream shall dissipate harmlessly.
 - c. All personnel shall be warned and kept clear of the discharge area during flushing operation.
 - d. Circulate water at 5 to 8 fps until no debris is caught at 5 micron strainer for 24 hours. Provide flushing machine with adequately sized pump to provide the flow required to reach stated velocities.
- 4. Steam Thermo Cycling:
 - a. Open all valves in the steam system piping including the branch lines except the valve at source and valves at equipment.
 - b. Open all piping drain valves including those at steam trap strainers.
 - c. At the control valves, if there is a by-pass line, open the by-pass valve but keep the block valves closed. If there is no by-pass line, open the control valve to the open position.

- d. Crack open the warm-up bypass valve and slowly warm up the piping system.
 - e. Raise the steam pressure in the system by gradually throttling the drain valves discharging steam.
 - f. Do not raise the steam pressure by further opening the main steam valve.
 - g. One by one, open the downstream valves at the steam traps and allow formed condensate to run into the condensate header. Run condensate from header to drain.
 - h. Leave the system under pressure for one hour. Close the steam valve and allow the system to cool down and to depressurize by condensation.
 - i. Repeat the thermo cycle 2 more times.
5. Condensate piping cleaning:
- a. Complete cleaning of steam piping before flushing of condensate piping.
 - b. Remove steam traps and connect a water hose to the downstream piping of a trap and flush towards the condensate receiver or the condensate header.
 - c. Drain the condensate receiver to floor drain and the condensate header to an approved drainage point.
 - d. When all trap discharge lines have been flushed, flush main condensate header with temporary piping or hose connection from the nearest city water main.
 - e. Provide temporary piping or hose from the end of the condensate header being flushed to an approved drainage point.
 - f. Connect steam and condensate at both ends. Circulate water at 5 to 8 fps until no debris is caught at 5 micron strainer for 24 hours. Provide flushing machine with adequately sized pump to provide the flow required to reach stated velocities.
6. Flush the condensate header with water from the city water main or an adequately sized flashing machine until a clear flow is obtained; method to be determined by a specific project design engineer.

7. Upon completion of flushing and cleaning operations, all temporary piping, pumps, strainers and baskets shall be removed from the piping system unless otherwise specified. Equipment and piping shall be returned to their pre-flush condition and permanent strainers must be cleaned.

n. IS-1 Steam and Condensate Piping Insulation in Tunnels /Vaults

1. Insulation material for piping:
- a. In tunnels steam and condensate piping insulation shall be single or multiple of 2 inch thick or 1-1/2 inch thick 2 piece pre-molded perlite block(s) with seams overlapped and staggered joints, tied together with wire; apply mastic at all joints between blocks. Wrap insulation with Alpha Matric rewettable material. After dried, cover with Childer CP10 with mesh to 30 mil wet thickness with 60% solid; after dried cover with another 30 mil wet thickness of CP10 with mesh.
 - b. At location exposed to water dripping, provide a 30 mil thick aluminum jacketing with aluminum straps, in addition to above.
2. Thickness: See Table 3G.03. The above thicknesses are provided as a guideline. Generally it is acceptable to match thickness of existing insulation. The intent is to provide an economic thickness to minimize heat loss and for personnel protection. The surface temperature should not exceed 100F in most instances.

Table 3G.03 Insulation Thickness Guidelines

Type	Pipe Size	Thickness
175 psig Steam	8 inch	4 inch
Condensate Drip Line	1 inch	1-1/2 inch
80 psig Steam	8 inch	4 inch
	4 inch	3 inch
Condensate Drip Line	1 inch	1-1/2 inch

G) UTILITIES SYSTEMS

4. GUIDELINES FOR UTILITY METERS AND CONTROL WIRING INSTALLATION

To provide requirements to project teams, project managers and contractors on steps required to ensure full installation of utility metering systems for the University of Chicago from physical placement of the meter to programming of software.

a. Purpose

For buildings connected to either of the University of Chicago’s central utility systems (steam and/or chilled water), a means of measuring the consumption in the facility is mandatory. The building’s function and usage will dictate the choice of metering schemes. See Figure 3G.04 Campus Utilities Metering Diagram and 3G.05 Campus Utilities Metering Schedule.

b-1. Physical Location/Installation of Meters

It is required that both steam and condensate meters be installed. The University standard steam meter is either Rosemount 3095MV flow meter with an Annubar (Rosemount requires an analog input) or GE Panametrics GS868 (GE requires a digital input). Steam meters must have RTD temperature sensors. For Rosemount contact Chanelle Ambrose at **708-478-5410**. For GE contact Dan Kilpatrick at 773-728-2373.

The pump room will have the Steam line PRV station and the steam meter (FM2) which should be located on the inside wall where the steam line enters the building. Layouts must show PRV and FM2. There should be an FM2 (steam meter) on the incoming steam **prior to** the PRV station, PRV station should be labeled on this riser.

For condensate, the standard is the Niagara flow meter WPX 210 with calibrated contact closure requires 1 input. Condensate meter should be labeled FM3; the following check valve should be used at the building main condensate receiver discharge pipe by the condensate meter

Durabla SCV Check Valve:

- Tight Shut-Off
- 1/2” to 3” Line size
- 750 to 3600 CWP
- NPT & SW ends
- 316 Stainless steel construction
- Inconel X-750 spring
- Spring-assisted silent closing
- Body guided disc

For chilled water, the University standard is the GE Panametrics DF868 requires 1 input. For all GE products contact Dan Kilpatrick with GE at 773-728-2373. Require two thermal wells and RTD’s (± 0.2°F accuracy) temperature elements. Flow meters at chilled water supply line upstream of chilled water bridge cross over piping. Provide 10” straight pipe upstream and 5” straight pipe downstream with no components in between. Contractor to coordinate with the Piping Sub-Contractor prior to piping installation. Outside of the building the chilled water line is 10” HDPE direct bury. Chilled water flow and temp switch should be located once the chilled water line enters the building along with chilled water flow meter (FM1) near the sensors.

Electric metering may be required, but this will typically occur only if a need for sub-metering has been identified for recharge purposes preference is the manufacturer 7650 series. All utilities meters must be hooked up and commissioned prior to utility use this includes Electric, Gas, Steam, Chilled water, Condensate and domestic water. Contractor should be carrying additional warrantee period from start up to substantial completion of these items. The FY11 university utility rates for steam is \$15.80 per M-lb and for chilled water is \$0.18 per tonhour, Contractor is responsible to pay for all utilities during construction including Electric, Gas, Steam, Chilled water, and domestic water.

All of these devices must be commissioned by the Project commissioning agent in conjunction with the Manufacturer.

b-2. Tasks for the A/E Team and Installation Team

- See Figure 3G.06A Metering Responsibility Matrix
1. Identify type/number of steam/condensate/chilled water/electric meters required based on building type and usage
 2. Determine model of meters
 3. Determine physical location of meters, ensuring that sensor/probe locations in/on the pipes to meet manufacturer and University requirements.
 4. Procure and Installation of piping, meters, sensors, probes, etc. (Installation team)
 5. Provide a factory validation/check-out sheet for EACH individual meter that was completed by the factory technician. Onicon, Niagara and Rosemount are done at the factory; GE does on-site. (Installation Team)
 6. Commissioning of the new meters must be coordinated through the BAS Shop (A/E Team, Project Commissioning Agent, University personnel, Manufacturers, Installation team)

G) UTILITIES SYSTEMS

Figure 3G.04 Campus Utilities Metering Diagram

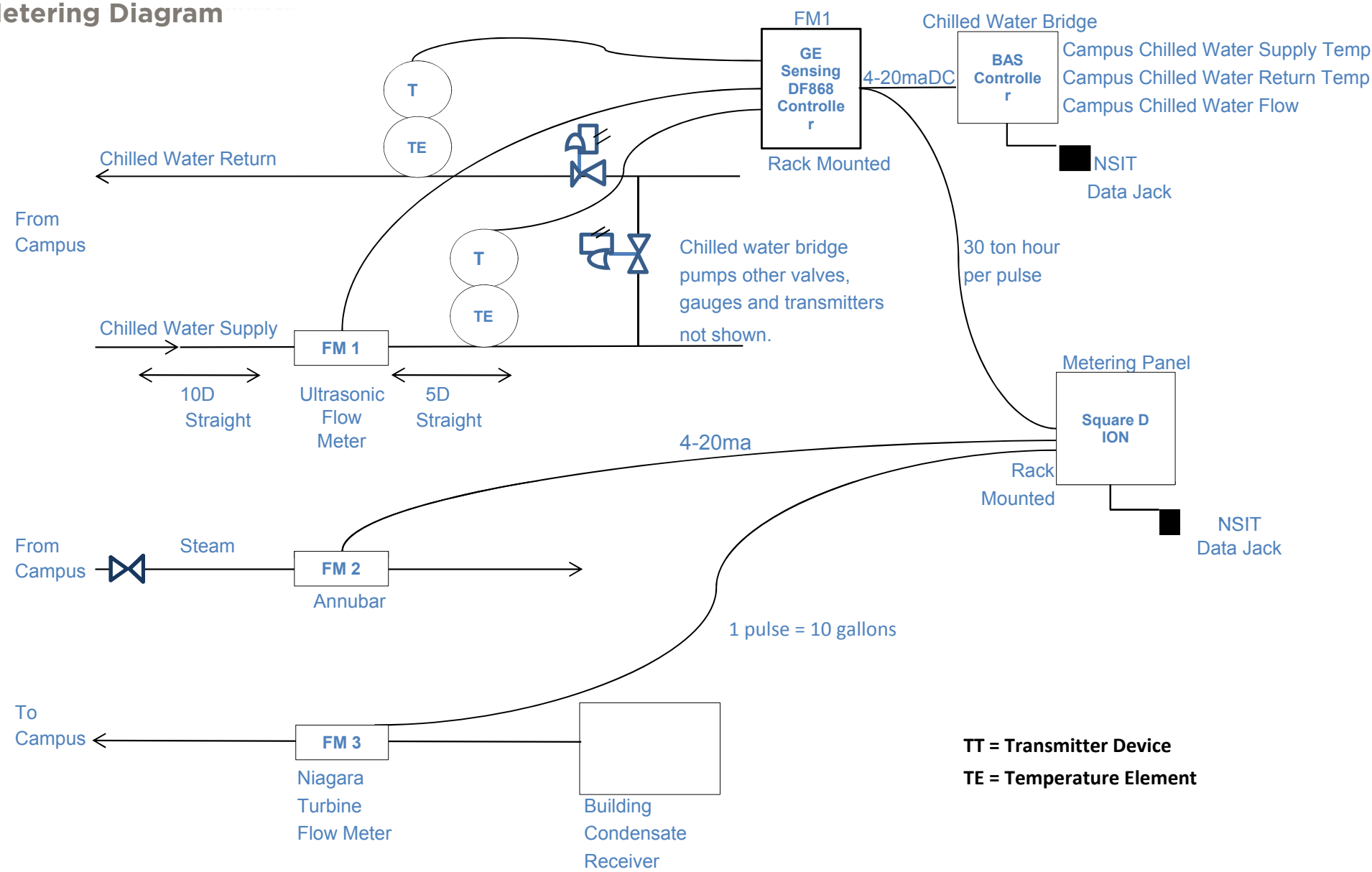


Table 3G.05 Campus Utilities Metering Schedule

	Type	Flow Range	Supply Temp.	Return Temp.	Pipe Size	Pressure	Remarks	Instrument Type
FM 1	Chilled Water Meter GE Sensing DF868	0-600 gpm	45°F	59°F	6 inch	40-120 psig	-	Ultrasonic Turbine
FM 2	Steam Meter: Rosemount 3095MV flow meter with an Annubar (Rosemount)	0-6,000 lbs/hr	Saturated to 45°F superheat	-	-	80 psig	Temp compensation for superheat	Annubar Vortex
FM 3	Condensate Meter Niagara WPX 210	12 gpm steady state; 30 gpm transient	-	-	-	-	-	Turbine

Note: All values are nominal; actual may vary

G) UTILITIES SYSTEMS

Table 3G.06A Campus Utilities Metering Schedule (Chilled Water, Steam, Condensate, and Electric)

Meter Type	General Contractor Responsibility			University Responsibility	
	Device / Vendor	BAS Contractor	Piping Contractor	NSIT	BAS Shop
Chilled Water Meter Controller (GE Sensing)		Furnish & Install			
Thermal Well		Furnish	Install		
RTDs		Furnish & Install			
Ultrasonic Meter		Furnish	Install		
Startup & Configuring	X	X		Oversight	Oversight
Input Wiring -Signal, Power		X			
Output Wiring to Metering Panel		X			
Steam Meter (Rosemont Mass Pro Bar)		Furnish	Install		
Ultrasonic Meter		Furnish	Install		
Startup & Configuring	X	X			
Input Wiring Power		X			
Output Wiring to Metering Panel		X			
Condensate Meter (Niagara)		Furnish	Install		
Ultrasonic Meter		Furnish	Install		
Startup & Configuring	X	X		Oversight	Oversight
Input Wiring Power		X			
Output Wiring to Metering Panel		X			
Electric Sub-Meter (3000/4000 series)		Furnish	Install		
Sub-Meter		Furnish	Install		
Startup & Configuring	X	X		Oversight	Oversight
Input Wiring Power		X			
Output Wiring to Metering Panel		X			

Notes:
1. Above work must be completed prior to providing temporary campus utilities for construction or project substantial completion, whichever comes first.
2. NSIT networking must be functional.

G) UTILITIES SYSTEMS

Table 3G.06B Campus Utilities Metering Schedule (Ion and BAS)

Meter Type	General Contractor Responsibility			University Responsibility	
	Device / Vendor	BAS Contractor	Piping Contractor	NSIT	BAS Shop
Ion Metering Panel					
Ion Panel		Furnish & Install			
Ion Meter		Furnish & Install			
Power		X			
Configuring	Schneider Electric			Oversight	Oversight
Point Mapping	Square D				
Database		X			
Termination of Input Wire		X			
IP Address				X	
Campus Network Connect Data Jack		X			
Metering input / output data verification	X	X			X
BAS Panel					
BAS Panel		Furnish & Install			
Power		X			
Configuring	Schneider Electric			Oversight	Oversight
Point Mapping	Square D				
Database		X			
Termination of Input Wire		X			
IP Address				X	
Campus Network Connect Data Jack		X			
Metering input / output data verification	X	X			X
Notes: 1. Above work must be completed prior to providing temporary campus utilities for construction or project substantial completion, whichever comes first. 2. NSIT networking must be functional.					

G) UTILITIES SYSTEMS

c-1. ION Meter Panel Installation

All newly installed meters will be connected to the UC ION energy management system. This ion meter panel allows for continuous recording of usage data and eliminates the need for manual meter reads. The ION panel is often referred to as a “meter”, but this device is actually a data collection/transfer point. Refer to the website for product information - <http://global.powerlogic.com/products>.

ION meter model # 7650 by Square-D and the usual part number is 9761E75RTUA1D3 with an Ethernet communication card and an option card that has Analog Input spots. Square D shall be the subcontractor used for all ION-related applications. The ION meter panel is connected to the building BAS system. Contractor to procure and install: the ION/BAS panels, all the meters, terminate meters wiring to ION panel, install ION panels, provide for Ethernet drops for NSIT connection, program ION panels. Re-configuration of UC ION database with new ION panels and meters, reconfiguration of UC BAS system with new BAS panels and meters is performed by the BAS Shop. Coordinate testing and commissioning of controls with the BAS Shop and NSIT. All meters purchased and installed by contractor NOT BY UC OR OWNER. The Installation Team shall be the combination of contractors and sub-contractors required to perform the task. The University personnel will oversee the contractors and sub-contractors work and verify that it meets University requirements.

c-2.Tasks for the A/E Team and Installation Team

See Figure 3G.06A & B Metering Responsibility Matrix

1. Determine appropriate ION panel model (A/E) (listed above)
2. Connect physical meter to ION panel (Installation Team)
3. Put in a request to UC NSIT for an IP address and an Ethernet drop(Installation Team)
4. Connect ION panel to campus Ethernet (Installation Team)
5. Program IP address for ION site (Installation Team)
6. Provide a factory validation/check-out sheet for EACH individual meter that was completed by the factory technician. (Installation Team)
7. Commissioning of ION meter panel (A/E Team, Project Commissioning Agent, University personnel, Manufacturers, Installation team)

d. ION System Programming

Programming the ION system will be required to ensure that live data from the meters reaches the ION server located in the Building Automation System (BAS) workshop in Regenstein Library. Without this programming, the meter will not register on the ION’s graphical user interface and thus the collected data will remain inaccessible to UC personnel. This data can be viewed graphically by two means: ION WebReach and ION Enterprise Energy Manager (EEM). WebReach allows the user to see real-time data through a graphical user-interface that includes a virtual map of the campus. ION EEM is a more robust data analysis tool that allows Facilities personnel and building owners to trend and analyze usage.

1. Program meters into ION server(Installation Team)
Tasks for Installation Team
2. Re-configuration of the University Ion system to accept the new panel (Installation team)
3. Create building/meter locations in WebReach and EEM (Installation Team)
4. **Make sure ALL meters have some sort of way to cycle power without needing to undo wires. (For example, installing a toggle switch in-line when installing a GE CHW meter.) (Installation Team)**
5. Provide a factory validation/check-out sheet for EACH individual meter that was completed by the factory technician. (Installation Team)
6. Commissioning of the new meters (A/E Team, Project Commissioning Agent, University personnel, Manufacturers, Installation team)

All items on the riser are procured and installed by Contractor. University BAS shop will oversee installation. Project Commissioning agent, Manufacturer and Installation Team are responsible for commissioning the system.

G) UTILITIES SYSTEMS

5. CAMPUS UTILITIES CHANGE AUTHORIZATION

Project manager name, phone number and email address:

Engineer name, phone number and email address:

Date:

Building name and number:

System affected:

Location of change:

Existing system information:

1. Flow: min, max, steady state and intermittent

2. Temperature: min, max, steady state and intermittent

3. Pressure: min, max, steady state and intermittent

4. Flow diagram: demand and consumption, equipment capacity, pipe size, valves, meters, regulators etc

5. Schematic diagram

Proposed change:

1. Describe addition or deletion of equipment with capacity information

2. Describe modification of system

3. Flow diagram, schematic (drawings or sketches) and physical drawings

Construction Information:

1. System shut down date and duration:

2. Other systems and occupants affected:

3. Construction start and end:

Notices to be issued:

1. Shut down notice

2. Hot work permit

3. Facilities Services area supervisor

4. Building permit

5. Energy Code review

System testing:

1. List all tests required

2. Test reports required

Close-Out:

Inspection date after modification:

As-built drawings:

Close-out signatures:

H) BUILDING ENVELOPE

1. INTRODUCTION

The building envelope, sometimes referred to as the “building enclosure”, is comprised of the various components, assemblies and systems that separate the interior environment of a building from the exterior environment. In establishing a boundary between the interior and exterior, the building envelope sets the conditions for the building mechanical and other environmental control systems to regulate the interior climate of the building.

a. Guiding Principles

The University of Chicago is a long term building owner and this is expected to have a significant impact on the Consultant’s approach to not just the overall exterior form of the facility, but also system selection and detailing. Aesthetics are important, but of equal importance are maintenance, component replacement, and long term performance of the building envelope assemblies.

- For planning and evaluation purposes, the University assumes the life expectancy of all of their facilities to be 100 years except in special circumstances.
- Various portions of the building envelope will need to be replaced numerous times over the life of the facility, and it is the Consultant’s responsibility in the design of the building to minimize the cost and inconvenience required for ongoing maintenance of the building envelope.
- Environmental impact is a concern of the University. Refer to sustainability requirements under “Related Sections”.
- The Consultant shall work with the University in building envelope system selection, and prepare and submit explanatory information, including but not limited to:
 - Pros and Cons of the various proposed systems
 - Listing of multiple sources where the building components can be purchased
 - Outline of performance expectations showing major repair and replacement events anticipated over the 100 year life cycle of the building
 - Special consideration related to historical replacement events and costs. Refer to heritage resources requirements under “Related Sections”.

- Materials and components of the building envelope systems shall be commonly available.
- The project design shall follow all applicable FM Global Property Loss Prevention Data Sheets (Engineering Guidelines). The FS Project Manager will coordinate the review of system designs with FM Global.
- Materials, components and systems of the building envelope shall be subject to independent testing and evaluation.
- The University strongly believes that many envelope performance problems are the result of inadequate coordination or detailing of the transitions between various building envelope systems. The Consultant is responsible to ensure coordinated detailing at each connection and transition between these component parts and assemblies, starting in the Schematic Design phase.
- Bird Safety: Birds play a vital role in nature, the environment and add beauty to the campus. The project shall comply with the Universty bird safety guidelines.

b. Related Sections

- Section C: Sustainability
 - In coordination with the University’s commitment to objectives as outlined in the Sustainability section of these Standards, implement a Life Cycle Cost Analysis (LCCA) for the development and selection of the materials, components and assemblies that comprise the building envelope. System selection shall consider the following:
 - History of system performance in the Chicago marketplace
 - Life cycle expectations based on non-warranty related data
 - Initial installation and long term maintenance costs

- Section F: Site, Civil and Grounds: Vines
 - The image of the University is enhanced by its ivy covered quad buildings. Additionally, the University encourages the protection of and continued planting of vines on or next to building walls. The benefits of the correct species of vines are many fold
- Section B: Heritage Resources
 - Determine applicability and requirements regarding alterations to existing building envelopes as they relate to the Heritage Resources program.

H) BUILDING ENVELOPE

2. BUILDING ENVELOPE COMMISSIONING

MATRIX (BECX)

The listing shown in Table 3H.01: Building Envelope Commissioning Matrix is a synopsis and does not contain all the information on the detailed duties of the commissioning agent during the delivery of service. an example of this is in the ASTM commissioning where the role of the agent in certain duties would include review of documents and testing and publishing a report to the owner. In the enhanced process the commissioning agent will perform the role with direct and substantive participation in addition to issuance of a report.

This listing is intended to serve as a general guide and is not to be used in the final determination of the nature of the services to be provided. Please review the referenced documents in making the determination of services that are included.

The NIBS guideline for enclosure commissioning is a guideline and not a standard. The depth or scope of services may therefore be modified. The ASTM document is a standards with strict adherence to the scope provided being a requirement.

Table 3H.01: Building Envelope Commissioning Matrix

Post Construction	Construction	Pre Construction	Design Documentation		Scope	Reporting	Schedule	BECx Team								
			Design Document Reviews	OPR / BOD												
Visit site to review performance 10 months post construction.	Attend systems training and operations meetings	Provide punch list	Review as bulits documents	Perform periodic site observation.	Review of 90% CD level drawings and specifications	Review of DD level drawings and specifications	Review of SD level drawings and specifications	Review and comment on Owners Basis of Design (BOD)	Active Participation in the development of the Basis of Design	Review and comment on Owners Performance Requirements	Enclosure commissioning team may be a qualified member of design, contracting or owner team.					
											Enclosure commissioning team may be a disinterested member of design, contracting or owner team. (for projects up to 20,000 sf. ASTM of fundamental)					
											Qualified Enclosure Commissioning team may not be a part of design, contracting or owner teams.					
											Enclosure commission to begin at concept stage					
											Enclosure commissioning to begin no later than commencement of the DD documents					
											Provide reports to the owner					
											Maintain a issues log					
											Develop a BECx Plan					

H) BUILDING ENVELOPE

3. GUIDELINES

a. Bird Safety

The University of Chicago places special importance on birds and their safety. Additionally, Chicago is located in a major flyway for migratory patterns in the spring and fall which increases the need for safety precautions.

The Mississippi Flyway is part of a larger migration route that extends from northwest Canada, along the Great Lakes, and down the Mississippi River Valley. Each year, more than 250 species of migratory birds use this flyway to travel between their winter habitats in the southern U.S. and Central and South America, and their summer habitats in North America. Chicago’s migratory season is from 17 March until 7 June and from 25 August until 25 October. With Lake Michigan to the east and farmland to the far west, Chicago’s green spaces provide a variety of plant life and habitat for resting and refueling. Since the University is within this important flyway, standards need to increase the safety of birds.

The FS2 document provides the opportunity for the University to become a leader in bird safe environments throughout the campus including buildings, landscaping and respect for bird habitats. Project management teams should use the Bird Safe Project Checklist in tandem with the LEED checklist to review design considerations during the Owners Project Requirement OPR and Basis of Design (BOD) development. **See Table 3H.01. Bird Safety Checklist.** Consultants should use the checklist on any project that would affect bird safety from window replacement, to landscaping, to new construction. Renovation projects that include existing conditions that could be improved for bird safety should also use the checklist.

Table 3H.01: Bird Safety Checklist					
This checklist serves three purposes: 1) assessing risk factors and determining risks which must be addressed; 2) increasing awareness of risk factors that are minimal and don't require treatment; and 3) evaluating buildings for bird-safe building certification.					
REQUIREMENTS FOR THE MOST HAZARDOUS CONDITIONS: The red shaded boxes indicate prohibited building conditions or conditions which are only permitted if the glazing is installed with bird-safe treatments. If the project combines a glass facade with a high risk location (Lines 3-4), glazing treatments will be required such that the amount of untreated glazing is reduced to less than 10% for the facade facing the landscaping or water. If a project creates a new bird trap or feature hazard (Lines 16-19) or remodels an existing feature-related hazard, bird safe treatment will be required.					
INCREASING AWARENESS: Use this checklist to evaluate design strategies for building new structures and retrofitting existing buildings. This checklist summarizes conditions that could contribute to bird mortality and will help to identify the potential risks. Interested faculty, staff, and students are encouraged to contact Facilities Services for suggestions on how to proactively increase awareness of these issues and make bird safety practices part of the campus conversation.					
VOLUNTARY RATINGS: Project design teams should use this form in evaluating bird-safe certification. Facilities Services will partner with these teams to acknowledge their work to actively reduce bird collisons. The ratings system will create tiers showing levels of meeting the bird safe criteria.					
RISK ASSESSMENT LEGEND					
	This shade indicates potential risk. The net assessment of total risk varies with the combination of factors -- only combinations with the "red" boxes present a risk level necessitating bird-safe treatments.				
	This shade indicates prohibited conditions or conditions which are prohibited unless bird safe treatment(s) applied.				
COMPLIANCE LEGEND					
By checking all of the boxes for one (or more) of these colors, it will indicate the level of compliance.					
	The building meets minimum conditions by focusing on ensuring "bird-hazards" and "bird-traps" are not created or are remedied.				
	Also reduces untreated glazing beyond requirements and commits to "lights out practices" and educating occupants.				
	Also reduces the amount of glass on the façade, avoids/treats additional hazards beyond requirements, and features year-round best management practices for lighting.				
				YES	NO
MACRO-SETTING	1	Is the structure located within a major migratory route? Chicago is part of the Mississippi Flyway.		X	
MICRO-SETTING (Location-related hazard)	2	Is the structure located such that windows greater than 24 sq ft will be opposite of, or will reflect, interlocking tree canopies?			
	3	Is the structure within 300 feet of an open space 2 acres or larger or dominated by vegetation?			
	4	Does the structure feature an above ground or rooftop vegetated area 2 acres or larger?			
GLAZING QUANTITY		Is the overall quantity of glazing as a percent of façade (risk increases with amount of glazing):			
	5	Less than 10%			
		More than 50%			
	6	Will glazing be replaced? More than 50% glazing to be replaced on an existing bird hazard (including both feature-related hazards as described below in Lines 16-19 and location-related hazard as described above in Lines 2-4).			
GLAZING QUALITY		Is the glazing quality of the glass best described as:			
	7	Transparent (If so, remove indoor bird attractions visible from outside the windows)			
	8	Reflective (If so, keep visible light reflectance between 10-20% and consider what will reflect in the windows. NOTE: Some bird-safe glazing such as fritting and UV spectrum glass may have higher reflectivity that is visible to birds)			
	9	Mirrored or visible light reflectance exceeding 30%			
GLAZING TREATMENTS	10	Is the glazing treated such that the "collision zone" contains no more than 10% untreated glazing for identified "location-related hazards" (Lines 2-4) and such that 100% of the glazing on "feature-related hazards" (Lines 16-19) is treated.			
	11	Is the building's glass treated for required "bird hazards" (as described in Line 10) and such that no more than 5% of the collision zone (lower 60 feet of façade) glazing is untreated but not for the entire building?			
	12	Is the glazing treated (as described in Lines 10 & 11) and such that no more than 5% on the exposed façade is left untreated?			

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

H) BUILDING ENVELOPE

For existing buildings in pursuit of the addition of new bird safety, contact the University Landscape Architect.

Table 3H.01: Bird Safety Checklist (Continued)				
BUILDING FAÇADE GENERAL	13	Is the building façade well-articulated (as opposed to flat in appearance)?		
	14	Is the building's fenestration broken with mullions or other treatments?		
	15	Does the building use unbroken glass at lower levels?		
BUILDING FEATURE- RELATED HAZARDS AND BIRD TRAPS		Does the structure contain a "feature-related" hazard of potential "bird trap" such as:		
	16	Free standing clear-glass walls, greenhouse or other clear barriers on rooftops or balconies?		
	17	Freestanding clear-glass landscape feature or bus shelters?		
	18	Glazed passageways or lobbies with clear sightlines through the building broken only by glazing?		
	19	Transparent building corners?		
LIGHTING DESIGN	20	Does the structure, signage or landscaping feature uplighting?		
	21	Does the structure minimize light spillage and maximize light shielding?		
	22	Does the structure use interior "lights out" motion sensors?		
	23	Is night lighting minimized to levels needed for security?		
	24	Does the structure use decorative red-colored lighting?		
LIGHTING OPERATIONS	25	Will the building participate in migration season mitigation programs? (Late Aug - late Oct; Mid March - early June)		
OTHER BUILDING ELEMENTS	26	Does the structure feature rooftop antennae or guy wires?		
	27	Does the strucure feature horizontal access wind generators or non-solid blades?		
CONSENT	28	Does the Building Manager agree to distribute bird-safe materials and notices to the building occupants?		

NOTE: Adapted from the City of San Francisco Planning Department 2011 Guidelines

H) BUILDING ENVELOPE

b) Function

The various functions of the building envelope are grouped into categories as indicated below. The Consultant shall address each of these in the design process, and clearly communicate them in the project documentation. Utilize drawings, narrative, diagrams, modeling, mockups, tours and other means as required to successfully communicate to the University’s staff and other project team members.

- **Support** – ability to resist and transfer structural loads (i.e. gravity, impact, wind, seismic, etc.)
- **Control** – method and capacity to regulate the flow of matter and energy
- **Finish** –desired aesthetics and surface characteristics

b-1. Support

The support elements of the building envelope are grouped into the building components indicated below. The project designer shall identify the support performance properties for each of these components during the design process, and clearly communicate them in the project documentation. Indicate the separate and combined loads for each component assembly, tolerances, and the anticipated movements under the design loading conditions and over time.

- Horizontal substructure (slabs-on-grade, earth-covered roofs, etc.)
- Vertical substructure (concrete foundation walls, masonry foundation walls, slurry walls, etc.)
- Floor construction (cast-in-place concrete slab edge, precast concrete slab edge, etc.)
- Wall construction (load-bearing masonry, lightweight steel framing, curtainwall, etc.)
- Openings (doors, windows, building system penetrations, etc.)
- Traffic Bearing Horizontal Enclosures (plazas, vegetated roofs, etc.)
- Roofing (flat membrane, sloped shingles, sloped metal, etc.)

The following and other applicable building and component movements should be considered.

- Building deflection (wind (LL), occupant (LL), structure (DL), etc.)
- System deflection capacity/resistance (L/600, L/360, L/240, etc.)
- Material expansion/ contraction (temperature, radiation, hygroscopic loading, etc.)
- Deformation (i.e. foundation settlement, concrete creep, etc.)
- Joint design (i.e. movement, capacity, layout, etc.)

Consider and provide for access to components of the building envelope, including maintenance and repair access, as well as construction site logistics.

b-2. Control

The control components of the building envelope are grouped into the barrier layers as indicated below. The project designer shall identify each of the layers in the building envelope during the design process, and clearly communicate them by means of building sections and details in the project documentation. Clearly indicate when a layer is intended to serve more than one function.

- Water barrier
 - Indicate type (i.e. membrane, rain screen, etc.)
- Air barrier
 - Indicate type (i.e. membrane, etc.)
 - Indicate the location of planned openings in the building envelope, how these openings are intended to interact with the building ventilation systems, and what mechanisms will be provided to regulate air migration through the openings.
 - Recognizing that air flow rates and pathways can change with air pressure difference patterns across the building envelope, separately indicate the likely scenarios for air pressure differentials

- Thermal barrier
 - Indicate type (rigid, semi-rigid, blanket, spray-applied, etc.)
 - Perform a dewpoint analysis for each type of building envelope assembly for typical heating and cooling design conditions. Note the anticipated duration of condensation events and drying potential.
- Vapor barrier (layer for control of water vapor diffusion)
 - Indicate type (membrane, concrete, unit masonry, etc.)
 - By means of building envelope sections and details, demonstrate the location and continuity of the barrier.
 - Indicate the vapor permeability for materials and assemblies.
 - Identify the layer in each building envelope assembly that is intended to serve as the assembly’s primary vapor barrier.
- Sunlight/radiant energy barrier
 - Indicate type, location, and performance parameters.
 - In concert with project Sustainability objectives, indicate areas of fenestration (vertical, sloped and horizontal) and other non-opaque elements in the building envelope.
 - Establish parameters for control of light transmission through these non-opaque elements for each exposure and condition in order to facilitate coordination with heating, cooling, daylighting, and other related building aesthetic and performance goals. Where applicable, indicate the following:
 - Visible light transmittance
 - Exterior reflectance
 - Shading coefficient
 - Solar heat gain coefficient
 - Light to solar gain ratio
 - In addition to fenestration, indicate other components of the design that are essential to the control of light transmission, such as light shelves, louvers, screens, etc.
 - Where appropriate to meet project performance and sustainability objectives, provide a dynamic daylighting model to assess the effect of natural lighting on thermal and lighting demands.

H) BUILDING ENVELOPE

- Sound/ vibration barrier
 - Indicate type, location, and performance parameters.
 - Project Manager in consultation with the Consultant will determine whether to undertake an environmental noise and vibration survey for existing conditions at the project site.
 - The building envelope shall be designed to limit sound and vibration transmission as required to achieve the programmatic requirements for interior noise and vibration levels.
 - Indicate the appropriate outdoor/indoor transmission class (OITC) necessary for the building envelope to attenuate exterior airborne sound to acceptable interior levels.
- Fire/ smoke barrier
 - Indicate type, location, and performance parameters.
 - Indicate the design listings (i.e. UL Design, etc.) being used in the building envelope to achieve the required fire/ smoke resistance ratings.

b-3. Finish

The finish components of the building envelope are grouped as indicated below. The project designer shall identify each of the finish properties in the building envelope during the design process, and clearly communicate them in the project documentation.

- Surface hardness
- Slip resistance
- Corrosion resistance
- Resistance to abrasion, erosion and general wear
- Appearance
- Ease of maintenance

c-1. Performance Criteria

These standards are intended for buildings that enclose a controlled environment. The application of these standards to buildings and structures of a more open nature (i.e. parking facilities, etc.) is subject to determination on a case by case basis.

- Reduce uncontrolled air movement through the building envelope.
- Heating climate. Limit interior moisture-laden air exfiltration through the building envelope.
- Cooling climate. Limit exterior moisture-laden air infiltration through the building envelope.
- Avoid negative affects to indoor air quality (IAQ) and occupant comfort resulting from air leakage through the building envelope.
- The design of building enclosure components shall incorporate elements to meet the air/water infiltration requirements through details that utilize a redundant system concept. Examples of this include, but are not limited to masonry cavity walls, rainscreen facades, and pressure-equalized curtainwalls.

c-2. Performance Criteria - Support

- Design each building enclosure system component to allow for their proper attachment to the structural frame of the building taking into account the fabrication and erection tolerances allowed for the elements of the frame and all predictable structural deflection.
- Maximum design criteria for predictable vertical structural deflections for the elements of the structural frame with superimposed load midspan vertical deflection limits between any two columns on the edge of any floor: L/600 (where “L” is the column spacing) or 3/8”, whichever is smaller.
- Maximum design criteria for horizontal building movement (interstory drift) at any floor: H/400; where H is the floor-to-floor height at that floor.
- Maximum anticipated long-term differential settlements for adjacent perimeter column foundations: 1/2” inch.

- Anticipated column shortening: 1/8” per 10 feet of column height.
- Design all parts of the building enclosure component for pressures and loads satisfying governing code but not be less than values specified herein
- Gravity Loads:
 - Dead Loads: Actual weight of all components and elements of the building enclosure system, and any associated materials.
 - Live Loads:
 - Roof Coping/Gutter Load: 500 lbs. on three square feet, located anywhere.
 - Interior Window Sills: 250 lbs. on 72 square inches, located anywhere.
 - Horizontal Wall System Projections wider than 6”: 20 psf maintenance load.
- Wind Loads: Horizontal design wind pressures.
 - The minimum design wind pressures shall meet or exceed the requirements of all applicable codes (i.e. Chicago Building Code, etc.).
 - In addition to applicable code requirements, design wind pressures shall be those derived from calculations or wind tunnel tests conducted by consulting wind engineers.
- Window Cleaning and Façade Maintenance Equipment Loads:
 - The Consultant, in consultation with the FS Project Manager and façade maintenance contractor, will determine the provisions necessary for proper maintenance and worker safety.
- Thermal Loads: Take into account self-straining forces and effects arising from expansion or contraction due to normally anticipated and design temperature ranges.
- Strength Requirements: Take into account analysis of loads and conditions of service for the installation.

H) BUILDING ENVELOPE

- Thermal Break Criteria: All curtainwall and window unit components are to be thermally broken to meet requirements of the condensation resistance requirements of this standard. Thermal breaks shall be designed per AAMA TIR A8, Structural Performance: Poured and Debridged Framing Systems.
- Joint Design:
 - Provide movement joints to accommodate the full range of manufacturing tolerance, thermal movement, floor, beam deflection and column settlement and to accommodate the worst possible combination of effects so as to prevent internal stress, oil canning, failure, deterioration or failure of weather seals.
 - Adequate accommodations such as sleeving should be made during detailing to allow for alignment from piece to piece with internal sleeves.
- Stiffness Requirements:
 - Aluminum and Steel: The maximum allowable deflections of the members under the action of gravity load or design wind pressures combined with appropriate gravity loads and thermal effects shall be as follows:
 - Design per AAMA TIR-A11, Maximum Allowable Deflection of Framing Systems for Building Cladding Components at Design Wind Loads.
 - Maximum allowable deflection: 0.125” in the plane of the wall; except 0.250” at corner mullions.
 - Compliance with these provisions shall be verifiable by the test methods of ASTM E330.
 - Glass:
 - Glass center deflection, relative to glass edges, at 50 percent of the appropriate design wind load, shall not exceed one (1) inch.
 - Glass deflection at 1.5 times the appropriate design wind load shall be limited to prevent glass disengagement from the frame.
- Connections/Attachments Requirements:
 - General: Design and detail connections and attachments to provide all resistance to forces and effects considered in their design. Prevent friction between connected materials from inducing unanticipated restraint by the use of appropriate friction-inhibiting detailing.
 - Gravity Load Connections: Design gravity load connections to not rely on friction between connected materials induced by bolt tension to transfer gravity loads at vertical slots.
- Wind or Thermal Connections: Provide wind or thermal connections with slotted or oversized holes or other approved means of non-restraint Snow Loads: Provide snow clips on the entire perimeter of the building where copings, sills, ledges, mullions or any projection is greater than 4”, unless otherwise recommended by consulting wind engineer.
- Fasteners:
 - As a minimum, conform to the requirements of industry standards.
 - Design fasteners to prevent loosening under all service conditions. “Lockable” fasteners must have a demonstrable and successful history of use.
- Provisions for Thermal Movements: Design and fabricate each component of the building enclosure system to allow for noiseless thermal expansion and contraction for unrestrained members, and to provide appropriate anchoring for restrained members, without causing undue stresses or other detrimental effects caused by changes in system component material temperatures and ambient air temperatures.
 - Ambient air temperature range: 130 °F (-30 °F low, 70 °F nominal and 110 °F high).
 - Material temperatures: Evaluate and provide for anticipated material surface temperatures, due to solar heat gain, and night sky heat loss, analyzed with the assumption of an interior temperature range of 45 °F to 100 °F.
- Material Degradation:
 - All dissimilar metals shall be effectively separated with bituminous/epoxy coatings or other suitable separation material as required to prevent galvanic action.
 - All materials which may cause staining, discoloring, degradation or other detrimental effects when in contact, shall be effectively isolated from each other.
- Animate Nuisance Control: Design each component of the building enclosure system to inhibit the unintended entry to the building interior through cavities and components of the system itself, insects and/or small animals, which would constitute a nuisance by their presence.

H) BUILDING ENVELOPE

c-3. Performance Criteria – Control

The Consultant shall review these performance criteria with project sustainability objectives established elsewhere in these Standards. In cases of conflict, the FS Project Manager shall determine the criteria to be used on the project in consultation with appropriate professional.

- Water Barrier: Design each component of the building enclosure system to prevent water penetration
 - Water penetration shall be as defined as the appearance of water other than condensation, on any interior surface of the building enclosure systems.
- Air Barrier: The **air infiltration resistance** of the building envelope is intended to comply with the minimum material, assembly and whole building standards indicated below, and with applicable code and regulatory requirements, whichever is more stringent.
 - **Materials: 0.004 cfm/sf @ 0.3 in w.g. (ASTM E2178)**
 - **Assemblies: 0.04 cfm/sf @ 0.3 in w.g. (ASTM E2357 or E1677)**
 - **Whole Building: 0.25 cfm/sf @ 0.3 in w.g. (ASTM E779)**
- Thermal Barrier:
 - The building envelope shall be designed to limit thermal transmission as required to achieve the project objectives for energy conservation and sustainability. Reference the Sustainability section of these Standards for further requirements.
 - Condensation Resistance: Design, fabricate, assemble and erect the enclosure systems for the project to provide the following condensation resistance:
 - General Condition: No uncontrolled or visible condensation shall form on any interior surface when the exterior temperature is -10 degree F with a 15 mph wind and the interior conditions are 72 degree F at a relative humidity of 30%.
 - Provide a continuous vapor barrier within the enclosure. The vapor barrier shall prevent water vapor from condensing within the wall assembly.

- In addition to normal primary weather/water control, provide secondary flashing systems to drain condensation and other sources of water to the exterior.
- Provide thermally broken window/curtainwall frame extrusions and detailing, to meet the specified condensation criteria.
- Vapor Barrier:
 - The building envelope shall be designed to limit vapor transmission as required to avoid undesirable moisture accumulation within the building envelope assembly, and to achieve the project objectives for energy conservation and sustainability. Reference the Sustainability section of these Standards for further requirements.
 - Permeability Resistance: Design, fabricate, assemble and erect the enclosure systems for the project to provide the following vapor resistance:
 - Materials: 0.01 perms (US) (ASTM E96)
 - Moisture migration and accumulation within the building envelope resulting in undesirable or deleterious conditions will be unacceptable.
 - Review building envelope materials for vapor permeability. Avoid conditions where moisture can be trapped between vapor barriers with no potential for drying.
 - Below grade vapor barrier must be capable of withstanding hydrostatic pressure.
 - Note: Bentonite has very poor water vapor permeability ratings. It should not be relied upon to provide the vapor barrier in a building enclosure.

- Sunlight/ Radiant Barrier:
 - The building envelope shall be designed to limit sunlight and other radiant energy transmission as required to achieve the project objectives for energy conservation and sustainability. Reference the Sustainability section of these Standards for further requirements.
 - Where appropriate to meet project performance and sustainability objectives, select glass and glazing materials and coatings that contribute to natural daylighting and exterior views while limiting undesirable radiant heat transmission.
- Sound/ Vibration Barrier:
 - The building envelope shall be designed to limit sound and vibration transmission as required to achieve the programmatic requirements for interior noise and vibration levels.
 - Indicate the appropriate outdoor/indoor transmission class (OITC) necessary for the building envelope to attenuate exterior airborne sound to acceptable interior levels.
 - Windows in the exterior wall of auditoriums, lecture rooms, conference rooms, classrooms and other similar spaces shall have a minimum rating of STC 35, unless otherwise recommended by the acoustical consultant.
- Fire/ Smoke Barrier:
 - Use of combustible materials in exterior envelope components is allowed only for non-load-supporting elements and is subject to the limitations of the building code for isolation, maximum flame spread, and the like.
 - Provide a complete fire containment system along the floor level perimeter including all exterior wall/floor or wall/roof junctures equal in rating to that required for the floor or roof assembly. The perimeter fire containment system shall prevent fire from spreading from floor to floor. Indicate the requirements of the UL listing for each condition. Adjacent work and conditions shall be coordinated with the appropriate containment assembly.
 - The building enclosure and systems shall receive the local code authority's approval.

H) BUILDING ENVELOPE

d. Material and Assembly Requirements

d-1. General Exterior Wall Requirements

- Exterior wall system shall have two continuous and separate lines of protection against water and air infiltration. Provide for pressure equalization and a weep system to drain the cavity created by the two separate lines of protection at each component part of the exterior wall.
- Design through wall flashings such that no modifications to the through wall system are required as other interconnected building systems are replaced.
- Provide a weep system at each line of flashing (including at the base of the wall) as required to insure positive drainage of the exterior wall.
- All anchors, supports and fasteners used for the attachment and support of exterior wall components shall be of corrosion resistant material.

d-2. Cast-in-Place Concrete Requirements

- Slabs-on-grade as components of the building envelope shall include a vapor barrier (retarder) between the bottom of the slab-on-grade and compacted aggregate subgrade, unless otherwise recommended by the consulting soils engineer.
 - Vapor barrier shall be a minimum 15 mils in thickness and meet or exceed ASTM E1745, Class A
 - Seal around pipes and other penetrations
- Reference the Accessibility section of these Standards for further requirements regarding floor surface flatness.

d-3. Precast Concrete Requirements

Design precast concrete systems in coordination with project LCCA activities where the University can expect a minimum of 50 or more years of overall system performance.

- All precast concrete panel joints shall be provided with two lines of seal (two-stage sealant joint) as conceptually presented within the PCI Architectural Precast Handbook.
- The exterior seal will be intermittently weeped/ vented/ baffled with water and moisture directed toward the exterior.
- The interior seal shall be as continuous as is practicable. This seal may be installed from the exterior or interior of the structure within a concept coordinated with guttering requirements, curtain wall and flashing systems.
- Single wythe precast concrete panels shall incorporate gutters within the air cavity on the back side of the panel that are weeped to the exterior through 3/8” inside diameter flexible tubing in a manner which will not stain the exterior face of the panel. Gutters shall be provided at a minimum of every two (2) stories of continuous precast panel.
- Insulating composite precast panels shall be designed to accept water drainage between the face mix and the integral insulation (i.e. drainage flutes within insulation).

d-4. Masonry Requirements

Design masonry assemblies and systems in coordination with project LCCA activities where the University can expect a minimum of **40** or more years of overall system performance. It is understood that this will likely require the design and installation of systems that are of higher quality and have longer-term performance than industry standards.

- Design, detailing and construction shall be consistent with best industry practices, and at a minimum with the following:
 - Brick Industry Association (BIA), Technical Notes on Brick Construction
 - National Concrete Masonry Association (NCMA), TEK Manual for Concrete Masonry Design and Construction
- Deflection for masonry supporting systems between support connections to the building structure shall be limited to length/600 or ½ inch maximum in any direction, whichever is less.

H) BUILDING ENVELOPE

d-5. Glass and Glazing Requirements

Design glass and glazing components of building envelope assemblies in coordination with project LCCA activities where the University can expect **20** or more years of overall system performance. It is understood that this will likely require the design and installation of systems that are of higher quality and have longer-term performance than industry standards.

- Design, detailing and construction shall be consistent with best industry practices, and at a minimum with the following:
 - Glass Association of North America (GANA), Glazing Manual
 - Insulating Glass Manufacturers Alliance (IGMA), North American Glazing Guidelines for Sealed Insulating Glass Units for Commercial & Residential Use
- Tempered Glass
 - Monolithic, fully tempered glass should be specified only where required to satisfy code, strength, and application requirements.
 - When monolithic, fully tempered glass is specified, the architect of record shall provide structural and thermal stress calculations when required by code or upon request from the University project manager (Facilities Services Operations/ Capital Project Delivery/Campus Planning + Sustainability).
 - All tempered glass to comply with ASTM C1048.
 - When specified, heat strengthened or laminated safety glass shall be used, even when a choice between them or tempered glass is allowed by code.
 - When monolithic, fully tempered glass is required and specified, an alternate price shall be requested for all tempered glass in the project to undergo heat soaking in accordance with EN-14179, Glass in Building – Heat Soaked Thermally Toughened Soda Lime Silicate Safety Glass.
 - Use post-tempering heat soaking requirements for specialized applications such as those near high traffic areas, over entrances, next to busy sidewalks, etc. In large applications that may have glass spiders or fins, laminated glass (SGP) is recommended.

- When heat soak testing in accordance with EN-14179 is provided, factory logs documenting heat soak testing of all monolithic, fully tempered glass for the project shall be submitted for approval by the architect of record and the University project manager.
 - For lites larger than 9sf, unless a substantial frit pattern is present to mask abnormalities, specify to minimize the impact of distortion
 - Produce all heat treated glass for a given project on the same equipment using the same processing parameters, and if possible, from the same batch
 - Consider a thicker outer lite to mitigate distortion
 - Orient heat treated glass so that the roller wave is parallel to the window sill/header
- Consultants shall coordinate with the University project manager to develop and enforce a project-based QA/QC program for all monolithic, heat treated glass, including tempered glass, that may include but is not limited to manufacturing and testing standards and documentation, roller wave and ripple tolerances and other distortions, transport and delivery requirements, and installation, verification and acceptance requirements.
- Quality assurance/quality control (QA/QC) - each project phase includes initiatives intended to increase compliance with project requirements and objectives by integrating quality assurance measures into the Project Development & Delivery Process. The Consultant shall develop and implement a complete quality assurance/quality control (QA/QC) program for the project based on the requirements in these Standards. Consistent with this effort, the Consultant will also be responsible that the design and documentation for the project establish coordinated QA/QC requirements for the Contractor.
- Argon filled insulating glass units are **NOT ACCEPTABLE**.
- Safety glazing shall comply with CPSC 16 CFR 1201 Categories I and II.

d-6. Glass and Aluminum Curtainwall Requirements

Design glass and aluminum curtainwall systems in coordination with project LCCA activities where the University can expect **50** or more years of overall system performance. It is understood that this will likely require the design and installation of systems that are of higher quality and have longer-term performance than industry standards.

- Design, detailing and construction shall be consistent with best industry practices, and at a minimum with the following:
 - Aluminum Association (AA)
 - Specifications for Aluminum Structures
 - Specifications for Aluminum Sheet Metal Work in Building Construction
 - American Architectural Manufacturers Association (AAMA)
 - CW-DG-1, Aluminum Curtain Wall Design Guide Manual
 - MCWM-1, Metal Curtain Wall Manual
 - SRM-1, Aluminum Storefront and Entrance Manual
 - National Association of Architectural Metal Manufacturers (NAAMM)
 - Metal Finishes Manual
- All components shall be selected and engineered to withstand applied wind pressures in accordance with sound and accepted engineering practice.
- Metal-to-metal joinery without the inclusion of a solid or closed cell elastomer, shall not be considered a watertight (face) seal.
- Minimal dependence shall be placed on sealants and caulking materials. Weeps and gutters shall be provided to drain to the outside any condensation and water, which may enter the pressure equalization chambers.
- System shall employ concealed weeps or drainage holes, baffled to prevent percolation.
- Where possible and practical, sealants employed as air seals shall be located so as to be accessible and maintainable, through the employment of sill covers, removable trim, etc.

H) BUILDING ENVELOPE

d-7. Windows

Select unit window systems in coordination with project LCCA activities where the University can expect **100** or more years of overall system performance. It is understood that this will likely require the selection, design and installation of systems that are of higher quality and have longer-term performance than industry standards.

- Design, detailing and construction shall be consistent with best industry practices, and at a minimum with the following:
 - Provide windows capable of complying with performance requirements indicated, based on testing manufacturer’s windows that are representative of those specified, and that are of minimum test size required by AAMA/WDMA 101/I.S.2/NAFS.
 - Acceptable frame materials include aluminum, steel, wood, aluminum clad wood. Application will vary by context & scope and is subject to approval by the University.
 - Minimum Standards include but not limited to:
 - National Woodwork Manufacturer’s Association: “Industry Standard for Wood Windows” 1-S-2-73, Class A
 - Architectural Aluminum Manufacturer’s Association: “Specifications for Aluminum Windows” Standard SW-1-68T, 60/25 H/H
 - National Association of Architectural Metal Manufacturers (NAAMM): Metal Finishes Manual
- All components shall be selected and engineered to withstand applied wind pressures in accordance with sound and accepted engineering practice.
- Metal-to-metal joinery without the inclusion of a solid or closed cell elastomer, shall not be considered a watertight seal.
- Minimal dependence shall be placed on sealants and caulking materials. Weeps and gutters shall be provided to drain to the outside any condensation and water, which may enter the pressure equalization chambers.
- System shall employ concealed weeps or drainage holes, baffled to prevent percolation.

- Where possible and practical, sealants employed as air seals shall be located so as to be accessible and maintainable, through the employment of sill covers, removable trim, etc.
- Replacement versus renovation - wood windows: existing wood window frames and sash should be examined for possible renovation. Although advances in replacement window unit design have improved (energy efficiency), maintaining historic character with reasonable energy efficiency can be achieved using traditional wood window + storm window configurations.

d-8. Doors and Frames

Select doors and frames in coordination with project LCCA activities where the University can expect **50** or more years of overall system performance. It is understood that this will likely require the design and installation of doors and frames that are of higher quality and have longer-term performance than industry standards.

- Design, detailing and construction shall be consistent with best industry practices, and at a minimum with the following:
 - American National Standards Institute (ANSI):
 - ANSI/DHI 115.IG – Installation Guide for Doors & Hardware
 - A250.4 – Test Procedure and Acceptance Criteria for Physical Endurance for Steel Doors and Hardware Reinforcings
 - A250.6 – Hardware on Standard Steel Doors-Reinforcement and Application
 - A250.8 – Recommended Specifications for Standard Steel Doors and Frames

- ASTM International (ASTM):
 - A366-97 – Standard Specification for Commercial Steel (CS) Sheet, Carbon (0.15 Maximum Percent) Cold-Rolled (Discontinued 2000)
 - A525 – Steel Sheet, Zinc-Coated (galvanized) by the Hot-Dip Process, Commercial Quality
 - A666 – Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
 - A924 – Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
 - E2074-00: Standard Test Method for Fire Tests of Door Assemblies, Including Positive Pressure Testing of Side-Hinged and Pivoted Swinging Door
- National Association of Architectural Metal Manufacturers /Hollow Metal Manufacturers Association (NAAMM/HMMA): 861 – Guide Specifications for Hollow Metal Doors and Frames
- National Fire Protection Association (NFPA)
- Steel Door Institute (SDI): SDI-109 – Hardware for Standard Steel Doors and Frames
- Underwriters Laboratories (UL)
- All components shall be selected and engineered to withstand applied wind pressures in accordance with sound and accepted engineering practice.
- Metal-to-metal joinery without the inclusion of a solid or closed cell elastomer, or fully welded connection shall not be considered a watertight (face) seal.
- Minimal dependence shall be placed on sealants and caulking materials.
- Where possible and practical, sealants employed as air seals shall be located so as to be accessible and maintainable, through the employment of sill covers, removable trim, etc.

H) BUILDING ENVELOPE

d-9. Waterproofing Requirements

Design waterproofing systems for below grade applications in coordination with project LCCA activities where the University can expect **40** or more years of system performance. It is understood that this will likely require the design and installation of systems that are of higher quality and have longer-term performance than industry standards.

- Incorporate life cycle cost control, practicality of installation, and ease of maintenance in the design.
- Utilize materials and systems that are time-proven.
- Take into consideration the sensitivity of the space, occupants and contents when selecting the appropriate system (i.e. library and museum archives will likely require systems with absolute system integrity and maximum watertight security).
- Investigate, select and design waterproofing components and systems that are compatible and work together with other elements of the building envelope to achieve performance requirements.
- Below grade horizontal waterproofing shall maintain an unobstructed minimum positive slope to drain of ¼ inch per foot, with a clear, concise drainage plan. All plaza drains shall be bi-level type.
- The Consultant is expected to:
 - Specify time-tested materials and assemblies.
 - When materials and assemblies without a proven record of successful performance in the local climate and environment are being proposed in order to meet other project objectives, the Consultant shall make recommendations for supplemental research and pre-testing, as required to satisfy the performance concerns of the University. This shall be completed prior to the end of the DD phase in order to identify and account for any impact to the project schedule and budget.

- Specify appropriate QA/QC requirements necessary to assure satisfactory completed work and reduced risk associated with removal of overburden materials normally associated with below grade waterproofing installations. These include, but are not limited to:
 - Testing of horizontal areas prior to installing topping materials by both of the following means:
 - Electric Field Vector Mapping (EFVM) in conjunction with the installation of a compatible conductive screen grounding layer below the waterproofing membrane.
 - Flood testing with standing water over the entire area for a period of 48 hours. (Note: Take the care necessary to avoid overburdening of the roof structure resulting from the accumulation of water not anticipated as a design condition.)
 - After passing the tests, immediately cover and protect the waterproofing membrane from any possible damage. At no point is the finished waterproofing system to be left exposed and vulnerable to damage.
 - Extensive on-site observation, verification and measurement of the installed work by the University’s waterproofing/roofing consultant or independent Testing Agency.
 - At the times indicated in the project schedule, submit waterproofing drawings and specifications as part of the building envelope documents for review by the University’s waterproofing/roofing consultant.

H) BUILDING ENVELOPE

d-10. Roofing Requirements

Design roofing systems in coordination with project LCCA activities where the University can expect many years of overall system performance. It is understood that this will likely require the design and installation of systems that are of higher quality and have longer-term performance than industry standards.

- Incorporate life cycle cost control, practicality of installation, and ease of maintenance in the design.
- Utilize materials and systems that are time-proven.
- Refer to FM Global Data Sheets and approved materials listings for roofing systems and related design criteria including those for green roof systems as applicable. It is expected that every consultant follow FM Global requirements.
- Take into consideration the sensitivity of the space, occupants and contents when selecting the appropriate system (i.e. library and museum archives will likely require systems with absolute system integrity and maximum watertight security).
- The Consultant is expected to:
 - Use time-tested materials and assemblies. When materials and assemblies without a proven record of successful performance in the local climate and environment are being proposed in order to meet other project objectives, the Consultant shall make recommendations for supplemental research and pre-testing, as required to satisfy the performance concerns of the University. This shall be completed prior to the end of the DD phase in order to identify and account for any impact to the project schedule and budget.
 - Investigate, select and design roofing components and systems that are compatible and work together with other elements of the building envelope to achieve performance requirements.
 - At the times indicated in the project schedule, submit roofing drawings and specifications as part of the building envelope documents for review by the University’s roofing consultant.
- Provide for roof access to all roof areas. This is important for observation and maintenance of the roof over its useful life.

- Construction:
 - Contractor shall have a minimum of 10 years of successful experience in the Chicago area installing the types of roofing indicated in the design drawings, including the roofing interfaces with adjacent and transitional elements in the building envelope.
 - Contractor shall employ experienced and properly skilled workers to install the roofing and underlayment work.
 - Frequent on-site observation and testing is recommended for roofing installations.
 - Objectives:
 - Monitor workmanship, weather conditions, and other elements that can affect the completion of a successful installation
 - Improve discovery and facilitate immediate correction of problems
 - Reduce risk from a problematic installation
 - The determination of whether a project merits full-time observation, or a reduced level, will be made by the Project Manger based upon the Consultant’s recommendation, the LCCA, budget and other factors.
 - Contractor shall prevent damage to new and existing materials, including but not limited to damage by personnel, ladders and other materials and equipment. Potentially damaging materials such as metal scraps, acid flux, and other debris shall not be allowed to come into contact with the roof surface.
- Low-slope roofs:
 - Unobstructed positive slope to drain from ¼ inch per foot to 2 inch per foot.
 - Design to meet FM 1-90 standards as a minimum. Higher wind standards may be required and it is the Consultant’s responsibility to determine when those higher standards should be incorporated into the project.

- Gravel Surfaced Built-up Roofing: Design gravel surfaced built-up roofing systems where the University can expect **30** or more years of overall system performance.
- Roofing system shall conform to the recommendations of the NRCA Roofing and Waterproofing Manual and the recommendations of the University’s roofing consultant.
- PVC Roofing:
 - Design PVC roofing systems where the University can expect **20** or more years of overall system performance.
 - Manufacturer shall have a demonstrated history of more than 20 years of successful roofing installations in projects with comparable climate and exposure.
 - Material and system testing shall demonstrate good resistance to industrial pollutants, bacterial growth, and extreme weather conditions.
 - PVC is incompatible with bitumen and polystyrene, and therefore care must be taken to avoid direct contact with these materials.
 - It is intended that PVC sheet roofing contain types, grades and quantities of plasticizers sufficient for long-term performance of the roofing membrane, without excessive degradation resulting from migration, exposure or aging.

H) BUILDING ENVELOPE

- Vegetated “Green” Roofing:
 - Design vegetated roofing systems where the University can expect **50** or more years of overall system performance.
 - Vegetated roofing is generally classified into two types:
 - Extensive (lower weight, tolerant plants only, and no regular traffic)
 - Intensive (heavier weight, wider variety of plants, and support recreational traffic)
 - Decisions to implement vegetated roofing in pursuit of project objectives must be weighed heavily, taking into consideration the life cycle cost of the system, ease of maintenance and difficulties with assessing and repairing potential leaks.
 - In the event that the FS Project Manager approves the use of vegetated roofing on the project, the Consultant will consider use of systems available from Sika Sarnafil as the preferred manufacturer, subject to the following criteria:
 - Manufacturer has a demonstrated history of more than 20 years of successful vegetated roof installations.
 - Systems and materials provide long-term protection from puncture, constant dampness, ponding water, root growth, heavy overburden, algae, and insects.
 - Systems and materials are compatible with the installation of a conductive screen grounding layer below the waterproofing membrane for use in electronic leak detection.
 - Single-source, 20-year warranty for extensive vegetated roof assemblies that includes overburden material, waterproofing and vegetated cover.
 - The Consultant is expected to specify appropriate QA/QC requirements necessary to assure satisfactory completed work and reduced risk associated with removal of overburden materials normally associated with vegetated roofing installations. Refer to the requirements for flood testing and EFVM in the “Waterproofing Requirements” section.
 - Tray type systems are NOT ACCEPTABLE due to roof maintenance concerns.
- Clay Tile Roofing:
 - Design clay tile roofing systems where the University can expect **75** or more years of overall system performance.
 - The University purchases clay tile and specialty fittings directly from the material supplier: Ludowici Roof Tile.
 - The Consultant shall provide a dimensioned roof plan, drawn to scale, for use by the supplier in performing material take-offs.
 - Lead time for specialty units and fittings can be as long as four months.
 - It is the joint responsibility of the Consultant and material supplier to make site inspections, so as to determine the quantities and locations of specialty fittings and avoid delays in shipping resulting from known lead time issues.
- Sheet Metal Roofing:
 - Design sheet metal roofing systems where the University can expect **40** or more years of overall system performance.
 - Material shall comply with National Coil Coater’s Association Technical Bulletins for factory color-coated steel.
 - Sheet metal items shall be in accordance with recommendations of The Architectural Sheet Metal Manual, published by the Sheet Metal and Air- Conditioning Contractors National Association, Inc. (SMACNA), unless noted otherwise.
 - Welding shall be in accordance with standard practices outlined in the American Welding Society (AWS), Code for Welding in Building Construction. All welds shall be completed by an AWS certified welder.
 - Copper roofing shall conform to the Standard Specifications for Sheet Copper Work published by the Copper Development Association, unless noted otherwise.
 - Skilled workers performing field soldering shall demonstrate their ability by preparing, field soldering and cutting open a minimum 12” long test seam in the presence of the independent Building Enclosure Consultant or Testing Agent.
- NOT ACCEPTABLE:
 - Lightweight insulating concrete deck is **not acceptable** for low –slope roofing installations.
 - Cementitious wood-fiber deck panels (commonly known by the brand name “Tectum”) are **not acceptable** for low – slope roofing installations.
 - Precast lightweight concrete deck panels are **not acceptable** for low –slope roofing installations.
 - Expanded polystyrene (EPS) and extruded polystyrene (EPS) insulation is **not acceptable** for roofing installations utilizing heat of sufficient temperature to pose the risk of melting the insulation (hot asphalt, induction welded membranes, etc.).

H) BUILDING ENVELOPE

d-11. Exterior Paints and Coatings

Protection of new and existing exposed exterior building components is paramount to the life of a building. The University expects its selected design team to select the most appropriate paint and/or coating system that meets FS2 standards. New fixtures, products, and/or systems should be prefinished/painted in shop prior to installation on site.

- Exterior systems and components that require proper protection include (but are not limited to):
 - Steel frames, heavy metal & medium metal
 - Exterior metal panels
 - Wood framed windows
 - Aluminum curtain wall & storefront
 - Steel framed windows
 - Wood door frames & doors
 - Aluminum door frames & doors
 - Steel door frames & doors
 - Roof systems: metal, or painted metal, flat seam, non-structural
- Selection and submittals: submittals, including samples, product data, & warranties, for all paints and coatings and associated colors shall be provided to the University for approval prior to issuing of bid documents. Application, surface preparation, maintenance requirements, and warranty information must be provided. This includes pre-finished components and systems.

- Products:
 - Paints and coatings shall be professional grade as opposed to contractor grade.
 - Approved Manufacturers (Paint & Coatings):
 - Pratt & Lambert
 - Sherwin-Williams
 - Pittsburgh
 - Benjamin Moore
 - Glidden Professional
 - Devoe High Performance Coating
 - PPG Industries
 - Quality Assurance
 - Single-source responsibility: Materials selected for each coating system and type of surface shall be the product of a single manufacturer
- Preparation of Surfaces:
 - Site Conditions:
 - Apply paints and finish products within the temperature range, humidity, and environmental conditions acceptable to the manufacturer of the product, as listed on the product label or product data sheet. Contractor and/or installer is to record temperature and humidity levels on days of coating application.
 - Protection: Prior to all surface preparation and painting operations, completely mask, remove, or otherwise adequately protect all surfaces and/or items in contact with painted surfaces but not scheduled to receive paint.

- Cleaning:
 - Before applying paint or other surface treatment, thoroughly clean all surfaces involved according to paint or finish coat manufacturer’s recommendations.
 - Schedule all cleaning and painting so that dust and contaminants from cleaning process will not fall on wet, newly painted surfaces or other finished surfaces.
 - Clean metal using chemical or mechanical methods recommended by the finish coat manufacturer for the metal substrate indicated. Thoroughly clean all surfaces until they are completely free from dirt, oil, and grease.
- Existing painted surfaces preparation:
 - Remove dust, dirt, residues, grease, oil, flaking or peeling paint, and correct all defects. .
 - Patch cracks and holes, sand smooth, and spot prime prior to finishing.
 - Feather edges at surface repairs.
- Priming:
 - Spot prime all exposed nails and other metals that are to be painted with emulsion paints using a primer recommended by the manufacture of the coating systems.
 - Prime surfaces as recommended by manufacturer of finish.
- Material Separation:
 - Separate dissimilar metals and other materials to prevent degradation, staining, etc.
- Installers:
 - The University requires that the installing Contractor have completed paint or coating applications similar in material, design, and extent as the Project calls for and that have resulted in a successful in-service performance.
 - Touch-up or repainting of surfaces shall cover the entire item, frame, or wall area. “Spot” touch-up work will not be permitted.

H) BUILDING ENVELOPE

e. Renovation/ Alterations

Although these Standards are generally written in the context of new construction, they are expected to be implemented in renovation and alteration work to the extent practicable, taking into account existing conditions, historical stewardship and other project specific conditions. As part of the design process, the Consultant will make recommendations regarding further investigations, reasonable adjustments to the standards and alternate courses of action necessary to achieve project objectives, for consideration by the FS Project Manager.

The following general guidelines shall be incorporated in renovation and alteration work involving the building envelope:

- Embrace the historic fabric and form of current building envelope components and assemblies, with minimal compromise to overall aesthetics.
- Identify the underlying functional characteristics of the existing building envelope in terms of Support, Control and Finish. Design alterations that are compatible with the existing construction, and with project performance objectives.
- Obtain a history of known non-performing characteristics of the existing building envelope.
- Develop a site logistics plan that minimizes disruption of occupancy, acknowledges the quality of life for students and staff, control interruptions of services including pedestrian and vehicular traffic, while maintaining a safe and productive workplace for the contractors, users and public for the duration of the project.
- Provide for full-time or discretionary periodic observation of the work by an independent Building Envelope Consultant and/or Testing Agency.
- Verify the availability of service providers that have been pre-qualified by the University for the type of work included in the project scope. Early in the project make recommendations regarding revisions to the service provider lists, as appropriate for the work.

f. Design Documentation

Coordinate and show each type of penetration through the building enclosure for such items including but not limited to lightning protection, electrical receptacles & boxes, exterior lighting, building signage, wall hydrants, exhaust ducts, etc. Indicate the methods for maintaining the integrity of each control barrier.

g. Performance Verification & Measurement

Early in the project schedule, the Consultant, Project Manager and other project team members will compare the risks and costs associated with potential remediation relative to the costs budgeted for design, construction and quality assurance activities. Based on this, the project team will determine the appropriate degree and extent of performance verification and measurement (V&M) activities to be included in the project. The extent of these activities will be re-evaluated periodically based on the complexity and proven-record for the component systems envisioned in the building envelope design.

- Materials, components and systems are unique or have unproven records of performance shall be identified early in the project schedule so that suitable verification, testing, measurement and assessment can be made prior to the end of the Design Development (DD) phase. Changes to the design may be required for unproven systems.
- Where appropriate, more robust quality control measures may be implemented on the project to better ensure adherence to the desired performance requirements. These may include additional material testing, mockup testing, field testing, thermal imaging, monitoring and measurement of the work on site.

h. Mockup Testing

Where mockup testing is included in the project V&M program, the project delivery method shall provide for the following:

- Provide all labor, materials, equipment and services required to install and test a full size mock-up of the wall system at the facilities of a recognized testing agency.
- Mock-up(s) shall include the furnishing and installing of all building envelope system components (i.e. masonry, precast concrete panels, aluminum and glass window system, insulation, flashing, glazing, gypsum board, and sealants) as specified for the portion of the building envelope being tested.
- Design Review of Mock-up: Upon completion of the erection of the mock-up, and prior to the commencement of any pre-testing, it shall be reviewed by representatives of the University and Consultant. This review shall be for general compliance with the visual design concepts of the building enclosure systems.
- Prior to the commencing of testing, the Testing Agency shall submit for review a detailed statement of the procedures and sequence of testing, the testing methods to be employed, the test loads, pressures, temperatures, etc. for each test, and the design performance requirements and evaluating methods for each test.

H) BUILDING ENVELOPE

i. Field Observation

Where field observation is included in the project V&M program, the project delivery method shall provide for the following:

- Retain an independent Building Envelope Consultant and/or Testing Agency to perform the field observations. To the extent practicable, they should be retained directly by the University.
- Testing Agency shall perform field observations and prepare reports.

Determine the degree and extent of field observation appropriate to meet the project accessibility objectives. This can vary from periodic observations to full-time, on-site monitoring of the work.

j. Field Testing

Where field testing is included in the project V&M program, the project delivery method shall provide for the following:

- Retain an independent Testing Agency to perform the field testing. To the extent practicable, the Testing Agency should be retained directly by the University.

4. REFERENCES

The Consultant shall become familiar with applicable federal, state and local regulations, and with current construction industry standards as applicable to the project design. Include those that are applicable in the design documentation for the project, and were appropriate indicate more stringent requirements as required to meet project goals. Unless otherwise required, the current editions and revisions of standards are applicable.

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

I) INTERIOR FINISHES & ACCESSORIES

1. INTRODUCTION

This portion of the Facility Standards includes interior finish and accessories guidelines to be followed by the Consultant in the course of a project at the University of Chicago. Materials should be selected for their appropriateness of use in the given area both for wear and performance. When specifying interior finishes, consideration should be given for a material’s: durability, ease of maintenance, safety (i.e. slip-resistance), high sound-absorption properties, low VOCs (volatile organic compounds), high light reflectance (especially at areas without natural daylight), high recycled content and locally sourced materials.

a. Sustainability

In keeping with The University of Chicago’s commitments to support sustainable initiatives, materials specifications should consider materials with: low VOCs (volatile organic compounds), high light reflectance, high recycled content and locally sourced materials.

Paints, adhesives, substrate materials and other finish specifications should emit no or low VOC’s. Specifying finishes (especially wall finishes) lighter in value will increase light reflectance within a room, possibly reducing the energy levels required to light a room. Utilizing materials with high recycled content and also specifying locally sourced materials helps to reduce landfill waste and carbon emissions expelled to transport goods cross country.

b. Renovation Projects

Renovation projects should give consideration to specifying materials which will coordinate with existing finishes (scheduled to remain) or provide some relief to removal and/or replacement of existing materials. For example, at areas where existing 4” high wall base is scheduled for removal, new wall base should be specified at 4 ¼” in order to conceal any marring at the drywall. Renovation projects retaining a great deal of existing conditions should encourage the design team to select finishes that will coordinate with and be maintained similar to existing finishes to remain.

2. GUIDELINES

a. Interior Finish Considerations

a-1. Durability

The selection of materials should primarily address the appropriateness of use in each given area. Level of wear (i.e.: high vs. low traffic areas) and resistance to staining and damage should be considered based upon the needs of each type of space. Consideration should be given for selecting materials with a stable construction, high psi (pounds per square inch) indentation resistance. Homogeneous sheet goods may provide superior durability at areas with high levels wear or heavy pivoting loads, including lab spaces. It is also encouraged to select materials that have proven performance records for 5 years or greater and warranties (material and labor to replace defective product) for 10 years or greater.

While performance-driven specifications are preferred, it is understood that budgets and programmatic needs will vary from project to project, which may call for some deviation from the priorities listed above. For example, while VCT (vinyl composition tile) flooring may not offer the best performance attributes, it is a cost-effective and readily available material and may be required per limiting project criteria. While these selections are not encouraged, variances from the guidelines may be considered on a case-by-case basis.

a-2. Ease of Maintenance

Finish specifications should allow for easy maintenance. Stain resistant materials, including solution dyed nylon carpets, vinyl flooring incorporating a stain resistant properties high-performance paints, and vinyl upholsteries support intentions to ensure long life-cycle performance by ensuring that materials can be easily cleaned to maintain a good appearance for a long period of time. Modular carpet allows for damaged sections of carpet to be easily replaced and the inherent cushion back provides better wear and more underfoot comfort. Broadloom carpets may be appropriate for areas with uneven floors; a cushion backing should be considered for these locations.

Carpets with a dense and low loop-pile structure offer better ease of maintenance and more longevity to the life of the product. It is advised to select carpets with pattern (and more than one yarn color) to aid in hiding soiled areas. Carpets medium to dark in color value will provide better stain hiding.

Laboratories, food service areas and high traffic spaces are subject to staining incidents and materials for these areas should be selected to have stain resistant properties to ensure long life-cycle performance. Sheet flooring, such as a vinyl with stain resistant properties and heat-welded seams meets stain resistant and slip resistant criteria important for a laboratory. Reduction of seams improves ease of maintenance.

No-wax flooring specifications should be considered as a building-wide strategy. No-wax flooring offers benefits in reduced maintenance costs, better slip-resistance and reduced environmental impact. Universal specification of the same or similar materials as much as possible allows for easier maintenance of facilities. Wax or no-wax solutions should also be reviewed with the sustainability and operations representatives at Facilities Services.

I) INTERIOR FINISHES & ACCESSORIES

a-3. Safety

Wet environments, including both areas with plumbing fixtures as well as lobbies and vestibules to the outside, should be given special consideration to receive flooring materials with a COF (coefficient of friction) of greater than .75.

a-4. Interior Glass

See Building Envelope Standards Section H for additional requirements.

a-5. Acoustical Control and Ceilings

Evidence-based design studies indicate that improved acoustical control in learning environments, and workspaces in general, contribute to better retention of information learned. In keeping with providing the best learning environments possible, it is strongly recommended the selection of materials give consideration for acoustical control in learning and work spaces.

Flooring materials like carpet and rubber flooring; ceiling tiles with high NRC (noise reduction coefficient) values and acoustical wall panels offer good sound control properties. Rooms accommodating a larger occupant loads should increase the sound absorption properties of materials.

Specifiers should refer to technical recommendations for sound transmission and reverb characteristics when evaluating materials for specification. Sound transmission loss (STC) is a single number rating system quantifying the transmission of sound between rooms.

Transmission of sound can be better controlled through construction mounting assemblies of walls and ceiling surfaces. The following matrix provides guidelines based upon these standards.

As ceilings are often accessed by mechanical engineers for maintenance and repair work, more robust 9/16 or 15/16” grids are preferred over thinner (Fineline) grids, which tend to get damaged easily. Specifiers should use a 15/16” grid at areas requiring mechanical equipment access above.

a-6. Attic stock

It is encouraged for facilities to adapt a streamlined approach to specifications in order to reduce product inventory and to ease maintenance. Each project should allow for some reserve of products specified to hold in attic stock. All materials must meet or exceed local code requirements. All materials should be installed in compliance with manufacturer’s instructions. It is encouraged that materials under consideration have been proven to work effectively in environments similar to the type of area it will be proposed for installation.

VOLUME III – DESIGN REQUIREMENTS

I) INTERIOR FINISHES & ACCESSORIES

b. Interior Finish Matrix

The selection of high-performing interior materials has a significant impact on the life-cycle performance of a building. The following matrices provide guidelines for specifications based upon room type. These room types are intended to represent a given room type’s specifications, regardless of what kind of building

the room occurs in. The matrix (Figure 3I.01) outlines criteria proposed to satisfy our most important objectives.

Table 3I.01 Interior Finish Matrix (1 of 4)

Room Type	Criteria	Floor	Base	Wall	Ceiling	Acoustics
Student: Private (Teaching)						
Classroom	Medium volume traffic, acoustical priorities, dimmable lighting	Homogenous sheet good: heat welded seams. Minimum 700 psi. COF >.65 dry. Minimum 10% post consumer recycled content, ISO >3dB	Flash coved integral or rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Fineline grid, ACT: >.65 NRC, >.85 LRV	STC 50
Lab - Dry	Medium volume traffic, acoustical priorities, dimmable lighting	Homogenous sheet good: heat welded seams. Minimum 700 psi. COF >.65 dry. Minimum 10% post consumer recycled content, ISO >3dB	Flash coved integral or rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Fineline grid, ACT: >.65 NRC, >.85 LRV	STC 45-50
Lab - Wet / Chemical	Medium volume traffic, acoustical priorities, dimmable lighting, wet spills, slip resistance, chemical staining	Homogenous sheet good: heat welded seams. Minimum 700 psi. COF >.75 dry. Minimum 10% post consumer recycled content, ISO >3dB. Ionomer impregnated (or equal) wear layer at chemical lab	Flash coved integral or rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Fineline grid, ACT: >.65 NRC, >.85 LRV	STC 45-50
Vivarium	Medium Volume of traffic, wet spills, slip resistance	Poured epoxy: Minimum 700 psi. COF >.75 dry. Minimum 10% post consumer recycled content	Flash coved epoxy (min 4”H)	Tile/high durability wall paint	Fineline grid, perlite ACT: >.65 NRC, >.85 LRV	STC 45-50
Book Stacks	Medium volume traffic, acoustical priorities	Patterned carpet (minimum of 2 yarn colors): Solution dyed, loop pile, min. 1/10 gauge, or Homogenous sheet good: heat welded seams. Minimum 700 psi. COF >.65 dry. Minimum 10% post consumer recycled content, ISO >3dB	Rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Fineline grid, ACT: >.65 NRC, >.85 LRV	STC 40
Computer Lab	Medium volume traffic, acoustical priorities	Patterned carpet (minimum of 2 yarn colors): Solution dyed, loop pile, min. 1/10 gauge, or Homogenous sheet good: heat welded seams. Minimum 700 psi. COF >.65 dry. Minimum 10% post consumer recycled content, ISO >3dB	Rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Fineline grid, ACT: >.65 NRC, >.85 LRV	STC 45-50
Sound Booth	Low volume of traffic	Minimum 700 psi.; COF >.65 dry; Minimum 10% post consumer recycled content	Rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Fineline grid, ACT: >.65 NRC, >.85 LRV	Per acoustical consultant

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

VOLUME III – DESIGN REQUIREMENTS

I) INTERIOR FINISHES & ACCESSORIES

Table 31.01 Interior Finish Matrix (2 of 4)

Room Type	Criteria	Floor	Base	Wall	Ceiling	Acoustics
Student: Private (Residential)						
Apartment: Student Room	Low level of traffic, acoustical properties	Patterned carpet (minimum of 2 yarn colors): Solution dyed, loop pile, min. 1/10 gauge, or Homogenous sheet good: heat welded seams. Minimum 700 psi. COF >.65 dry. Minimum 10% post consumer recycled content, ISO >3dB	Wood or rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Drywall or concealed grid, ACT: >.65 NRC, >.85 LRV	STC 50
Kitchen: Private	Low volume of traffic, wet spills, slip resistance	Minimum 700 psi. COF >.75 dry. Minimum 10% post consumer recycled content	Flash coved, painted wood or Rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Drywall	STC 50
Lounge	Low volume of traffic	Patterned carpet (minimum of 2 yarn colors): Solution dyed, loop pile, min. 1/10 gauge, or Homogenous sheet good: heat welded seams	Rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Fineline grid, ACT : >.65 NRC, >.85 LRV	STC 50
Restroom: Private	Low Volume of traffic, wet spills, slip resistance	Poured epoxy / porcelain / ceramic tile or other easily cleanable, impact resistant flooring: Minimum 700 psi. COF >.75 dry. Minimum 10% post consumer recycled content	Flash coved epoxy/PT cove (min 4”H)	Porcelain or ceramic tile/ high durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Drywall	STC 50
Back of House						
Copy Room / Storage	Medium volume traffic, acoustical priorities, dimmable lighting, chemical staining	Homogenous sheet good: heat welded seams, or: Quartz tile product or equal. Minimum 700 psi. COF >.65 dry. Minimum 10% post consumer recycled content, ISO >3dB	Rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Fineline grid, ACT : >.65 NRC, >.85 LRV	STC 40
Janitor’s Closet	Low volume of traffic, wet spills, chemical staining, slip resistance	Sealed concrete or: Quartz tile product or equal	Flash coved or rubber (min 4”H)	Epoxy paint or wall protection	-	STC 40
Staff: Private						
Conference	Medium volume traffic, acoustical priorities, dimmable lighting	Patterned carpet (minimum of 2 yarn colors): Solution dyed, loop pile, min. 1/10 gauge, or Homogenous sheet good: heat welded seams. Minimum 700 psi. COF >.65 dry. Minimum 10% post consumer recycled content, ISO >3dB	Rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Fineline grid, ACT: >.65 NRC, >.85 LRV	STC 50-55
Office	Low volume of traffic	Patterned carpet (minimum of 2 yarn colors): Solution dyed, loop pile, min. 1/10 gauge	Rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Fineline grid, ACT: >.65 NRC, >.85 LRV	STC 45-50

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

VOLUME III – DESIGN REQUIREMENTS

I) INTERIOR FINISHES & ACCESSORIES

Table 3I.01 Interior Finish Matrix (3 of 4)

Room Type	Criteria	Floor	Base	Wall	Ceiling	Acoustics
Semi-Private						
Auditorium Lecture Hall	High level of traffic, acoustical properties, dimmable lighting	Patterned carpet (minimum of 2 yarn colors): Solution dyed, loop pile, min. 1/10 gauge, or Homogenous sheet good: heat welded seams. Minimum 700 psi. COF >.65 dry. Minimum 10% post consumer recycled content, ISO >3dB	Recessed metal or solid wood	Specialty acoustical panels	Specialty acoustical panels	Per acoustical consultant
Restroom: Public	High Volume of traffic, wet spills, slip resistance	Poured epoxy / porcelain tile / ceramic tile or other easily cleanable, impact resistant flooring: Minimum 700 psi. COF >.65 dry. Minimum 10% post consumer recycled content	Flash coved epoxy/PT cove (min 4”H)	Porcelain tile/ high durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Fineline grid, perlite ACT : >.65 NRC, >.85 LRV	STC 50
Locker Room	Medium Volume of traffic, wet spills, slip resistance	Poured epoxy / porcelain tile / ceramic tile or other easily cleanable, impact resistant flooring: Minimum 700 psi. COF >.75 dry. Minimum 10% post consumer recycled content	Flash coved epoxy/PT cove (min 4”H)	Porcelain tile/high durability wall paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Drywall or aluminum grid with moisture resistant ACT	STC 50
Showers	Medium Volume of traffic, wet spills, slip resistance	Poured epoxy / porcelain tile / ceramic tile or other easily cleanable, impact resistant flooring: Minimum 700 psi. COF >.75 dry. Minimum 10% post consumer recycled content	Flash coved epoxy/PT cove (min 4”H)	Porcelain tile/high durability wall paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Drywall or aluminum grid with vinyl skinned or perlite ACT	STC 50
Semi-Public						
Multi-Purpose	Medium volume traffic, acoustical priorities	Patterned carpet (minimum of 2 yarn colors): Solution dyed, loop pile, min. 1/10 gauge, or Homogenous sheet good: heat welded seams. Minimum 700 psi. COF >.65 dry. Minimum 10% post consumer recycled content, ISO >3dB	Rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Fineline grid, ACT: >.65 NRC, >.85 LRV	STC 45-50
Dining Area	High volume of traffic, wet spills, slip resistance, acoustical properties	Homogenous sheet good: heat welded seams. Minimum 700 psi. COF >.65 dry. Minimum 10% post consumer recycled content	Flash coved or rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Fineline grid, ACT: >.65 NRC, >.85 LRV	STC 45-50
Kitchen Cafeteria	High volume of traffic, wet spills, slip resistance	Homogenous sheet good: heat welded seams. Minimum 700 psi. COF >.75 dry. Minimum 10% post consumer recycled content	Flash coved or Rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Fineline grid, vinyl skinned or perlite ACT: >.65 NRC, >.85 LRV	STC 45-50

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

VOLUME III – DESIGN REQUIREMENTS

I) INTERIOR FINISHES & ACCESSORIES

Table 31.01 Interior Finish Matrix (4 of 4)

Room Type	Criteria	Floor	Base	Wall	Ceiling	Acoustics
Public						
Corridor	High level of traffic, slip resistance, acoustical properties	Homogenous sheet good: heat welded seams. Minimum 700 psi. COF >.65 dry. Minimum 10% post consumer recycled content, ISO >3dB	Flash Coved or Rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Fineline grid, ACT: >.65 NRC, >.85 LRV	STC 50
Lobby	High Volume of traffic, wet spills, slip resistance	Minimum 700 psi. COF >.75 dry. Minimum 10% post consumer recycled content	As required	As required/ high durability paint (100% acrylic latex, VOCs NTE 48 grams/liter)	As required	STC 45 - 50
Stairwells	High Volume of traffic, wet spills, slip resistance	Homogenous sheet good: heat welded seams. Minimum 700 psi. COF >.65 dry. Minimum 10% post consumer recycled content	Rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Fineline grid, ACT: >.65 NRC, >.85 LRV	STC 45 - 50
Entry Vestibule	High level of traffic, slip resistance, acoustical properties	Recessed walk off grate or walk off mat (solution dyed, absorption >1.5 gal/sq yd)	Rubber (min 4”H)	High durability, low VOC paint (100% acrylic latex, VOCs NTE 48 grams/liter)	Drywall OR Fineline grid, moisture resistant or perlite ACT: >.65 NRC, >.85 LRV	STC 45 - 50
Performance	High level of traffic, acoustical properties, dimmable lighting	Patterned carpet (minimum of 2 yarn colors): Solution dyed, loop pile, min. 1/10 gauge, or Homogenous sheet good: heat welded seams. Minimum 700 psi. COF >.65 dry. Minimum 10% post consumer recycled content, ISO >3dB	Recessed Metal or Solid Wood	Specialty acoustical panels	Specialty Acoustical Panels	Per Acoustical Consultant
Retail Area	High Volume of traffic, wet spills, slip resistance	Minimum 700 psi. COF >.65 dry. Minimum 10% post consumer recycled content	As required	As required / high durability paint (100% acrylic latex, VOCs NTE 48 grams/liter)	As required	STC 45-50
Seating Area	Medium volume of traffic, wet spills, slip resistance	Minimum 700 psi. COF >.65 dry. Minimum 10% post consumer recycled content	As required	As required / high durability paint (100% acrylic latex, VOCs NTE 48 grams/liter)	As required	STC 45-50

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

I) INTERIOR FINISHES & ACCESSORIES

c. Hardware Standards

This portion of the Facility Standards includes hardware requirements to be followed by the Consultant in the course of a project at the University. The hardware components include:

- 1. Hinges
- 2. Offset Pivots
- 3. Locksets
- 4. Cylinders
- 5. Exit devices
- 6. Closers
- 7. Flushbolts and Strikes, Wall and Floor Stops, Coordinators
- 8. Electric Strikes
- 9. Electronic Access-controlled Locksets
- 10. Electromagnetic Locks
- 11. Electromagnetic Doorholder/Releases
- 12. Overhead Stops
- 13. Thresholds
- 14. Other Hardware and Finishes

c-1. Hinges

- a. Hinges shall conform to ANSI A156.1 and have the number of knuckles as specified, oil-impregnated bearings as specified with NRP (non-removable pin) feature at reverse bevel interior doors or where specified and, at all exterior reverse bevel doors. Unless otherwise scheduled, supply one (1) hinge for every 30” of door height. Hinges shall be a minimum of 4 1/2” high and 4” wide; heavyweight hinges (.180) shall be supplied at all doors where specified. McKinney, Hager are the preferred manufacturers.
- b. Electric hinges shall be provided with Molex standardized plug connectors to accommodate up to twelve (12) wires. Plug connectors shall plug directly into Molex through-door wiring harnesses for connection to electric locking devices and power supplies. Provide sufficient number of concealed wires to accommodate electric function of specified hardware. Provide a mortar guard for each electric hinge specified. McKinney is the preferred vendor.
- c. Monitoring switch hinges to be magnetic reed, concealed,

adjustable switch type with extra heavy magnet. McKinney is the preferred manufacturer.

- d. Continuous geared door hinges are to meet the following design criteria:
Continuous geared configuration, designed to distribute loads uniformly. Identical operation in each leaf, designed to reduce door opening effort. UL labeled for 3 hour fire classification.
Durability tested to ANSI/BHMA A156.26 Grade 1, 2, 3.
 - 1. Pemko, Select, Rotan are the preferred manufacturers.
 - 2. Continuous geared hinges shall be full mortise type, extruded tempered aluminum, 6063-T6 alloy, with three interlocking extrusions in pinless assembly, installed to full height of frame.
 - 3. Hinges shall be available with the following hinge options:
Safety, Short leaf flush, Short leaf inset, Standard, Safety short leaf inset, Center pivot.
 - 4. Hinges shall be available with the following electrical modifications: Thru wire, monitoring, preparation for electric power transfer or removable access panel for wire connections.
 - 5. All hinges shall be heavy duty: 27 bearings each leaf for 83 inch (2108 mm) hinge, minimum door weight 540 lb, with mortise fasteners: TEK, #12 x 3/4 inch, FHUC, Phillips head screws.
 - 6. Hinges shall carry a fire Label certification and comply with ASTM E2074, NFPA 1, UBC 7-2, BS 476, UL 10B, UL 10C, [90 minutes for wood doors] [3 hours for hollow metal doors].
 - 7. All hinges shall be tested according to ANSI/BHMA A156.26.

- 8. Electrified hinges shall have the an option for a removable section (Serviceable) module for ease of installation and the ability to upgrade without purchasing a new hinge if electrification is added at a later date. They shall use 22 gauge polyurethane coated wire, be available with 4’ and 10’ wire leads to facilitate installation and hook- up.

9. Field cutting of hinges shall not affect the fire rating.

10. Warranty:

Aluminum hinges carry a life of the opening warranty
Electrified hinges carry a 5 year warranty

- e. Continuous pin & barrel stainless steel hinges are to meet the following criteria:
Pin & barrel stainless steel full mortise continuous hinges shall be full height providing full door support up to a 48” door maximum width and /or 600 lbs.
Material to be 14 gauge stainless steel, .25 diameter stainless steel pin except medical bearing option with exterior barrel diameter of .438 (7/16”).
Hinges to be manufactured with symmetrically templated hole pattern, non- handed, with each knuckle 2” including split nylon bearing at each separation for smooth self-lubricating operation.
Markar is the preferred manufacturer.

VOLUME III – DESIGN REQUIREMENTS

I) INTERIOR FINISHES & ACCESSORIES

c-2. Offset Pivots are to meet the following criteria:

- All pivots and pivot sets shall be of one manufacturer.
- All heavy duty pivots shall have a minimum of 2 bearings internal to the bottom pivot. One shall be a thrust bearing and the other a needle bearing. Separate bearing surfaces shall be in the top pivot.
- Lead-lined door units and high traffic pivots shall have additional thrust bearing.
- Fire rated pivot (up to 3 hour) sets shall have steel top pivots. Fire rated doors require steel intermediate pivots.
- Unless otherwise scheduled, at door equipped with offset pivot sets, supply one (1) intermediate pivot for every 30" of door height.
- Electrified pivots shall be available with 4, 6, 8 or 12 wires to accommodate electrical requirements and shall include a Molex type connector.
- Units shall be available in all standard architectural finishes
- Rixson is the preferred manufacturer.

c-3. Locksets

a. Mortise locksets are to meet the following criteria:

- Locks shall have all functions available in one size case, manufactured from heavy gauge steel, minimum thickness 3/32 inch, completely chrome plated for corrosion resistance and lubricity of parts. Cases shall be closed on all sides to protect internal parts.
- Locks shall have adjustable, beveled and armored fronts, secured with spanner head security screws. Standard 2-3/4 inch backset convertible from one function to another, with a full 3/4 inch throw two-piece mechanical anti-friction latch bolt and a one piece stainless steel 1" throw dead bolt. Internal parts shall be heavy gauge steel, zinc dichromate-plated for corrosion resistance and nickel steel hubs. Locks shall be available for field reversible handing without opening the lock case.
- Locksets to have cycle testing certified by an independent third party witness, exceeding 10,000,000 cycles.

1. Corbin Russwin is the preferred manufacturer.
2. All locksets with latch bolts, regardless of trim, shall be listed by UL for A label and lesser rated doors, 4'0" x 10'0" single door or 8'0" x 10'0" pairs of doors.
3. Locksets to be used on specified exterior doors or doors subject to special atmospheric conditions (roofs, pool areas, chemical laboratories, greenhouses, etc.) shall have non-ferrous cases and critical internal components.
4. Locksets provided for doors into stairwells, exits, electrical rooms, mechanical rooms, elevator pits or any other hazardous areas shall have knurled or tactile warning lever handles.
5. Lock trim shall have solid steel levers (hollow or filled levers are not acceptable) with minimum 2" diameter wrought roses, through bolted through the lock case to assure correct alignment and proper operation. Lock trim to be equal to Corbin Russwin NSA design.
6. Lockset functions shall be determined by the UC project coordinator according to the planned usage of the opening.
7. Locksets to have a 10-year limited mechanical warranty.
8. Provide curved lipped strikes for all mortise locksets.
9. Locksets shall be ordered "LC" (less cylinder). The University Lock shop will supply and install all lock cylinders.
10. Locksets to have the following available options:
 - Occupancy indicators
 - Lead wrapped cases
 - Ergonomic – ADA-approved thumbturn levers
 - Electrified locksets – 12v or 24v
 - Electric monitor options
 - Anti-microbial coating
- 11) Lock trim to be equal to Corbin Russwin NSA, NSM or NSN design.

c-4. Cylinders

- ##### a. Medeco High Security cylinders are required for all University installations. The University will supply construction cores and permanent cylinders, along with necessary keys. Locksets shall be specified to coordinate accordingly.
1. The lock cylinders are to be of a high security, pick resistant design with angled key cuts, rotating tumblers, a keyway side biting, and a slider mechanism. Cylinders shall be Underwriters Laboratories Listed Standard--UL437--for key locks. Cylinders shall be certified under American National Standards Institute (ANSI)/Builder's Hardware Manufacturer's Association (BHMA) certification A156.30 2003 (High Security Cylinders Products), "Levels M1AAAM" and ANSI/BHMA A156.5 2001 (Certified Auxiliary Locks & Associated Products) "Grade 1."
 2. The cylinders shall incorporate three locking elements, consisting of a slider mechanism, a sidebar mechanism with tumbler rotation, and pin tumbler elevation. The critical parts of the locking mechanism such as pins, shear line, sidebar, and slider mechanism shall be afforded extra protection from drilling and other forceful attack by the strategic placement of hardened steel inserts in at least 7 possible locations within the cylinder. The lock tumblers shall combine a dual-axis action, with one axis utilized for pin tumbler rotation and the other axis utilized for positioning key cuts. Randomly selected tumbler pins shall incorporate a hardened steel insert for additional drill protection.
 3. The locking system is to be furnished in a restricted key section for which keys are not made available from the manufacturer's factory or any other source by normal distribution methods. The key and cylinder must have utility patent protection so as to ensure against unlawful key duplication. The keys and key blanks must be capable of being furnished to allow an upgrade to a dual mechanical and electronic credential by the single exchange of a field removable key bow. The key thickness should be no less than .125" (one hundred, twenty-five thousandths).

I) INTERIOR FINISHES & ACCESSORIES

4. The manufacturer shall have the capability of establishing a key system with a minimum of six angle cuts in six possible pin positions with the capability of two distinct positions of cut per pin chamber, if required by the parameters of the system. The manufacturer shall have the capability of producing a patent-protected keying system in either of two distinct and different keying specifications and pinning specifications. The system shall be capable of incorporating a key which is capable of more than one bitting per position to expand master keying and key changes. The key shall also incorporate the capacity to include twelve possible side bittings along the key blade located on two different planes or surfaces of the key. The system shall also have the capability to provide a single master key with over 1,000,000 (1 million) usable, non-interchangeable change keys in a single keyway.
5. The cylinders shall be immediately rekeyable to new combinations or a new system at any time desired and shall be serviceable on location in the field. Installation of cylinders shall require no modification to U.S. manufactured commercial grade locksets.
6. The University will furnish the manufacturer a list of those persons and their signatures that will be authorized and required to order additional pinned materials or duplicate keys. Orders not bearing authorized signatures will not be filled.

c-5. Exit devices

- a. Exit devices are to have met or exceeded the following extended cycle testing in accordance with Underwriters Laboratory:
 - Rim devices- 54,000,000 cycles
 - Mortise devices-51,000,000 cycles
 - Surface vertical rod devices-16,000,000 cycles
 - Concealed vertical rod devices- 20,000,000 cycles
 - Rim devices with electric latch retraction- 13,000,000 cycles
1. Von Duprin is the preferred manufacturer.
2. Push-through touch pad design. No exposed touch bar fasteners, no exposed cavities when operated. Return stroke fluid dampeners and rubber bottoming dampeners, plus anti-rattle devices.
3. Minimum ¾” throw deadlocking latchbolts.
4. No exposed screws to show through glass doors.
5. Non-handed basic device design with center case interchangeable with all functions, no extra parts required to effect change of function.
6. Releasable with 32 lb. maximum pressure under 250 lb. load to the door.
7. Heavy cast metal flush mounted end caps finished to match exit device.
8. Specific features:
 - Provide standard hex key dogging on non fire-rated exit devices, with cylinder dogging as an option if requested
 - Lever Trim: Breakaway type, forged brass or bronze escutcheon min .130” thickness, match lockset lever design.
 - Rod and latch guards with surface vertical rod devices.
 - Fire-Labeled Devices: UL label indicating “Fire Exit Hardware”. Vertical rod devices less bottom rod (LBR) unless otherwise scheduled.

- Delayed Egress Devices: Function achieved within single exit device component, including latch, delayed locking device, request-to-exit switch, nuisance alarm, remote alarm, key switch, indicator lamp, relay, internal horn, door position input, external inhibit input plus fire alarm input. NFPA 101 “Special Locking Arrangement” compliant.
 - Electrically Operated Devices: Single manufacturer source for electric latch retraction devices, electrically controlled trim, power transfers, power supplies, monitoring switches and controls.
 - Removable Mullions: Removable with single turn of building key. Securely reinstalled without need for key. Furnish storage brackets for securely stowing the mullion away from the door when removed.
 - Manufacturer to furnish one (1) parts maintenance kit per project.
 - Exit devices shall have a 5 year limited warranty.
- b. Power Supplies: Power supplies are to provide filtered, regulated power to operate electrical products including electrified exit devices. Output power is to be field- selectable for either 24VDC @ 2 ampere or 12VDC @ 4 ampere. Standard input is to be 120VAC @ 1.0 ampere. Steel enclosure shall incorporate key lock and have minimum quantity of five knockout holes for conduit connection. Terminal block to accept up to 14 gauge wire.
 - c. Electrical Power Transfer Devices: Fully concealed when door is closed, power transfer device is to have two 18 gauge or ten 24 gauge wires as indicated by model scheduled.

I) INTERIOR FINISHES & ACCESSORIES**c-6. Closers**

- a. Specify single manufacturer for closer units throughout the project, including surface closers, high security closers, overhead concealed closers, floor closers, low-energy door operators and electromagnetic hold-open closers.
 1. LCN is the preferred manufacturer.
- b. Surface closers are to meet the following criteria:
 1. Full rack-and-pinion type cylinder with removable non-ferrous cover and cast iron body. Double heat-treated pinion shaft, single piece forged piston, chrome-silicon steel spring.
 2. ISO 2000 certified. Units stamped with date-of-manufacture code.
 3. Independent lab-tested 10,000,000 cycles.
 4. Thru-bolts at wood doors unless doors are provided with closer blocking. Non- sized, and adjustable. Place closer inside building, stairs, and rooms.
 5. Plates, brackets and special templating when needed for interface with particular header, door and wall conditions and neighboring hardware.
 6. Maximum opening pressure: Exterior doors 8.5 lb., interior doors 5 lb., labeled fire doors 15 lb.
 7. Separate adjusting valves for closing speed, latching speed and backcheck, fourth valve for delayed action where scheduled.
 8. Extra-duty arms (EDA) at all doors scheduled with parallel arm units.
 9. Exterior door closers: tested to 100 hours of ASTM B117 salt spray test, furnish data on request.
 10. Exterior doors do not require seasonal adjustments in temperatures from 120 degrees F to –30 degrees F, furnish data on request.
 11. Non-flaming fluid will not fuel door or floor covering fires.

c. Low-Energy Door Operators:

1. Where a “Low Energy Power Operated Door”, as defined by ANSI Standard A156.19, is indicated for doors required to be accessible to the disabled, provide electric powered operators complying with accessibility ADA requirements.
2. Full closing force shall be provided when the power or assist cycle ends.
3. Modular design, adjustments easily accessible from the front, UL listed for use on labeled doors.
4. Operators shall have “Second Chance” function to accommodate momentary resistance, “Breakaway” function in the electronically controlled clutch, “Soft Start” motor control function and “Maintain Hold-Open Switch” to hold the door open at 90 degrees.
5. Operators shall have built in 12V and 24V power supply for actuators, card readers, electric strikes and magnetic door locks, inputs for both swing and stop side sensors and available to accept either 120VAC or 220VAC input power. All wiring connections between operator modules made by easy-to-handle electrical connectors. Shall comply with both UL and NEC requirements for Class 1 and Class 2 wiring by providing separate conduits for each. Provide “fail-open” or standby power for accessible egress doors where required.
6. Shall have seven independent electronic adjustments to tailor the operator for specific site conditions. Opening speed, holding force at 90 degrees, sequential trigger and time delay, hold-open time at 90 degrees, opening force, clutch “breakaway” force setting, electric strike trigger and time delay.
7. Shall have separate and independent adjustments for back check, main speed and latch speed.
8. Furnish actuators and other controls as specified in Hardware Sets.

c-7. Flushbolts and Strikes, Wall and Floor Stops, Coordinators

- a. Automatic flush bolts shall be UL listed for use in pairs or as single top bolt with auxiliary latch for labeled pairs of wood or hollow metal doors. Top bolts are to have no internal spring, thus reducing reduced activation force.
 - 1) Rockwood, Ives are the preferred manufacturers.
- b. Constant latching flush bolts shall be UL listed for use in pairs or as single top bolt with auxiliary latch for labeled pairs of wood or hollow metal doors. Low actuation forces. Inactive door will re-latch automatically.
- c. Manual flush bolts shall be provided in pairs, be non-handed, fit standard ANSI metal door prep and be UL listed for use on doors with fire ratings up to 3 hours. Bolts shall have minimum 5/8” bolt throw with 7/8” vertical adjustment. Top bolt rod shall be provided in length to position activating lever not more than 80 inches above the finished floor.
- d. Dustproof strikes to be spring loaded plunger type, with locking ring for use with threshold, or mounting flange for installation where no threshold is present. Dustproof strikes shall be manufactured by the same manufacturer as flushbolts to assure proper fit. They shall have a removable faceplate for use with thresholds and be adjustable for varying flooring conditions.
- e. Wall stops shall be wrought stainless steel, concealed fastening, concave bumper that resists yellowing, cracking and aging, with fasteners to suit wall construction, back-plate should contact wall to prevent ‘cookie-cutter’ damage to substrate.
- f. Floor stops shall be solid cast brass with bumper that resists yellowing, cracking and aging, plastic or lead anchor options and available riser for varying floor conditions.
- g. Coordinators should be used with automatic flushbolts and non-handed. Stop mounted channel 1-5/8” x 5/8” steel tubing x length to suit door opening. Coordinator shall be UL listed. Furnish filler bars to fill gap between end of coordinator and inactive door frame. Furnish mounting brackets for all stop mounted hardware such as exit device strikes, door closer PA shoes, etc. Coordinators shall be prepared (cutout) at the factory for surface applied or concealed vertical rod panic devices if required

I) INTERIOR FINISHES & ACCESSORIES

c-8. Electric strikes

- a. All standard electric strikes shall be tamper resistant all stainless steel construction for corrosion resistance, strength and durability and be compatible with metal or wood applications.
 - 1. HES 1006 Series, Folger Adams 700 Series are preferred manufacturers.
 - 2. Strikes shall have been tested to withstand a forcing strength of a minimum 2400 lbs. before releasing and perform with a minimum of one million cycles of operation.
 - 3. Strikes shall be dual voltage, either 12VDC or 24VDC continuous duty, fail-secure unless otherwise specified.
 - 4. Strikes shall be non-handed with an internally mounted solenoid. Provide an in-line power controller with all electric strikes.
 - 5. 5 Year Limited Warranty.
 - 6. Optional Features and Accessories:
 - FAIL-SAFE
 - Latchbolt monitor (LBM)
 - Latchbolt Strike Monitor (LBSM)
 - 27 Interchangeable face plate options
 - Plug-in bridge rectifier
 - ElectroLynx adapter
 - Smart Pac III – power controller
- b. All surface mounted electric strikes shall be tamper resistant, all stainless steel construction for corrosion resistance, strength and durability and be compatible with metal or wood applications.
 - 1. HES 9500 Fire-rated/9600 series is the preferred manufacturer.
 - 2. Strike shall have an internally mounted solenoid and two stainless steel independently operating locking mechanisms. All components to be completely encased within ¾” thick stainless steel housing – requiring no cutting to the jamb.
 - 3. Strikes shall have been tested to static strength of 1,500 lbs, and dynamic strength of 70 ft-lbs, and perform with a minimum of 500,000 cycles of operation.

- 4. Strikes shall be field selectable to either 12VDC or 24VDC continuous duty, fail- safe or fail-secure operation.
- 5. Strikes shall be non-handed, and be able to accommodate up to a 3/4” Pullman latch. Provide an in-line power controller with all electric strikes.
- 6. 5 Year Limited Warranty.
- 7. Optional Features and Accessories:
 - a. Latchbolt monitor (LBM)
 - b. Plug-in bridge rectifier
 - c. ElectroLynx adapter
 - d. Smart Pac III – power controller

c-9. Electronic access-controlled locksets

- a. Wireless Electronic Mortise type Locksets are to meet the following criteria:
 - 1. Mortise type lockset to have with 3-piece, beveled, stainless steel latchbolts with ¾” throw and equipped with an anti-friction latch. Chassis will accommodate ANSI standard mortise lock prep with a 2 3/4” nominal backset for 1 3/4” doors as a standard, with 1 3/8” to 2 3/4” thick doors in 1/8” increments available. Locksets will be non-handed. Lockset to meet or exceed A156.25 and A156.13 Series 1000, Grade 1 Operational and Security.
 - 2. Lockset to meet UL10C, FCC Part15, ADA compliant, NFPA 101, NFPA 80, IBC- Ch10, Industry Canada RSS-210, Florida Building code ASTM E3300
 - 3. Wireless Transmission / Encryption: AES-128 bit Key minimum.
 - 4. Lockset to be manufactured with open architecture characteristics capable of handling new and existing access control software and credential reading technology.
 - 5. Lockset to be modular in design, to have the ability to change credential reader without being removed from door.
 - 6. Locking escutcheon, security lever trim and to be non-handed, operate independently of non-locking levers for extended life cycles. Handing to be field reversible.
 - 7. Exterior lever to be designed with ability to rotate freely while door remains securely locked, preventing damage to internal lock components from vandalism by excessive force.

- 8. Lockset and Exit Device Trim to have the following standard status switches: Lock/Unlock Status (Clutch Position), Request-to-Exit Switch, Request to Enter Switch, Door Position Switch, Deadbolt Position, Interior Cover Tamper Guard.
- 9. Lockset to communicate Battery Status and Communication Status.
- 10. Furnish locks with following functions which will be field configurable without taking the lock off the door:
 - a. Classroom / Storeroom 70.
 - b. Apartment 60.
 - c. Office 50.
 - d. Privacy 40.
- 11. Lockset powered by a 12V or 24V DC power supply.
- 12. Should power be lost to device, Lockset to have the ability to be field configured to manage access control in one of the three field configurable methods below:
 - a. Fail locked (secured)
 - b. Fail unlocked (unsecured)
 - c. Fail As-Is
- 13. Should communication be lost between device and network, Lockset to have ability to manage access control offline in one of four field configurable methods below:
 - a. Fail locked (secured)
 - b. Fail unlocked (unsecured)
 - c. Fail As-Is
 - d. Fail to Degraded/cache mode utilizing cache memory with following selectable options:
 - Grant access up to the last 1,000 unique previously accepted User IDs
 - Grant access up to the last 1,000 unique previously accepted Facility/Site codes
 - e. Knurling option to provide tactile feedback to be available.
- 14. Lockset and Exit Trim system interface to be:
 - a. Wiegand or Clock & Data via PIM400 (Panel Interface Module).
 - b. Directly via RS485.

VOLUME III – DESIGN REQUIREMENTS

I) INTERIOR FINISHES & ACCESSORIES

15. Lockset to have real-time communication with access control system, such that all events at Lockset are communicated real-time to network control software.
16. Lockset and Exit Device Trim utilized with 3rd Party software to have capability to be remotely locked down real-time, within 10 seconds or less, without user interface at the device.
17. Lockset and Exit Device Trim utilized with 3rd Party software to have capability to be remotely unlocked real-time without user interface at the device.
18. Lockset to have visual tri-colored LED to indicate operational systems status, system error conditions and low power conditions.
19. Lockset to have audible feedback that can be enabled or disabled.
20. Credential reader capabilities for SMS Select/Premier/Enterprise Software or 3rd Party Partner integrated software may include and may not be limited to:
 - a. 13.56 MHz Smart card credentials:
 - Secure section (Multi-Technology and Smartcard): Schlage, XceedID ISO-X, MIFARE, ISO-X Lite, my-d, DESFire 8-EV1.
 - 13.56 MHz Serial number only (Multi-Technology and Smartcard): MIFARE, DESfire, iClass, Inside Pictotag, ST Micro, TI Tagit.
 - b. Multi-Technology readers that read both 13.56 MHz Smart Cards + 125 kHz Prox cards.
 - c. Dual credential reading capabilities credential card/fob + pin.
 - d. 12 button keypad with backlit buttons.
21. The lock and exit device trim will have the ability to utilize multiple manufacturer's key systems in the lever including:
 - a. Full Size cylinders for Medeco 6-pin cylinders.
 - b. Full Size Interchangeable Cores for Medeco 6 pin cylinders.
22. Provide option for tamper torx screws on inside escutcheon for Higher Security.
23. Acceptable Manufacturers: Schlage Electronics AD-400-MS/MD Series
 - b. Wireless Electronic Access Controlled Exit Device Trim:
 1. Exterior lever to be designed with ability to rotate freely while door remains securely locked, preventing damage to internal lock components from vandalism by excessive force.
 2. Modulation to be 900 MHz spread spectrum, direct sequence, 10 channels.
 3. Transmission / Encryption: AES-128 bit Key minimum.
 4. Exit device trim to have Wake-Up on radio feature which enables implementation of wireless locks in applications where centralized lockdown or unlock is required. This is to enable real-time activation at a remote battery-powered wireless lock.
 5. Exit device trim to retract the Von Duprin latch bolt of following exit device applications: rim, surface vertical rod, concealed vertical rod and mortise.
 6. Exit devices to be equipped with low current request to exit switch.
 7. Exit Device Trim to meet UL10C, FCC Part15, ADA compliant, NFPA 101, NFPA 80, IBC-Ch10, Industry Canada RSS-210, Florida Building code ASTM E3300
 8. Exit Device Trim to be manufactured with open architecture characteristics capable of handling new and existing access control software and credential reading technology.
 9. Exit Device Trim to be modular in design, to have the ability to change credential reader in the field.
 10. Locking escutcheon, security lever trim and to be non-handed, operate independently of non-locking levers for extended life cycles. Handing to be field reversible.
 11. Exterior lever to be designed with ability to rotate freely while door remains securely locked, preventing damage to internal lock components from vandalism by excessive force.
12. Exit Device Trim to have the following standard status switches: Lock/Unlock Status (Clutch Position), Request-to-Exit Switch, Request to Enter Switch, Door Position Switch, Interior Cover Tamper Guard.
13. Exit Device Trim to communicate Battery Status and Communication Status.
14. Furnish locks with following functions which will be field configurable without taking the lock off the door:
 - a. Classroom / Storeroom 70.
 - b. Apartment 60.
 - c. Office 50.
 - d. Privacy 40.
 - e. Knurling option to provide tactile feedback to be available.
15. Exit Device Trim powered by a 12V or 24V DC power supply.
16. Should power be lost to device, Exit Device Trim to have the ability to be field configured to manage access control in one of the three field configurable methods below:
 - a. Fail locked (secured)
 - b. Fail unlocked (unsecured)
 - c. Fail As-Is
17. Should communication be lost between device and network, Exit Device Trim to have ability to manage access control offline in one of four field configurable methods below:
 - a. Fail locked (secured)
 - b. Fail unlocked (unsecured)
 - c. Fail As-Is
 - d. Fail to Degraded/cache mode utilizing cache memory with following selectable options:
 - Grant access up to the last 1,000 unique previously accepted User IDs
 - Grant access up to the last 1,000 unique previously accepted Facility/Site codes

I) INTERIOR FINISHES & ACCESSORIES

- 18) Lockset and Exit Trim system interface to be:

a. Wiegand or Clock & Data via PIM400 (Panel Interface Module).

b. Directly via RS485.

19. Exit Device Trim to have real-time communication with access control system, such that all events at Exit Device Trim are communicated real-time to network control software.

20. Exit Device Trim utilized with brightblue software or 3rd Party software to have capability to be remotely locked down real-time, within 10 seconds or less, without user interface at the device.

21. Exit Device Trim utilized with 3rd Party software to have capability to be remotely unlocked real-time without user interface at the device.

22. Exit Device Trim to have visual tri-colored LED to indicate operational systems status, system error conditions and low power conditions.

23. Exit Device Trim to have audible feedback that can be enabled or disabled.

24. Credential reader capabilities for SMS Select/Premier/Enterprise Software or 3rd Party Partner integrated software may include and may not be limited to:

a. 13.56 MHz Smart card credentials:

· Secure section (Multi-Technology and Smartcard): Schlage, XceedID ISO-X, MIFARE, ISO-X Lite, my-d, DESFire 8-EV1.

· 13.56 MHz Serial number only (Multi-Technology and Smartcard): MIFARE, DESfire, iClass,Inside Pictotag, ST Micro, TI Tagit.

b. Multi-Technology readers that read both 13.56 MHz Smart Cards + 125 kHz Prox cards.

c. Dual credential reading capabilities credential card/fob + pin.

d. 12 button keypad with backlit buttons.

25. The lock and exit device trim will have the ability to utilize multiple manufacturer’s key systems in the lever including:

a. Full Size cylinders for Medico 6-pin cylinders

b. Full Size Interchangeable Cores for Medeco 6 pin cylinders

26. Provide option for tamper torx screws on inside escutcheon for Higher Security.

27. Acceptable Manufacturers: Schlage Electronics AD-400-993 Series Exit Device Trim

c. Panel Interface Module:

1. Used for communication of wireless lockset or exit device trim to the access control panel.

2. To have the following certifications: NEMA1, 4, 4X, 6; 294, FCC Part 15; RoHS.

3. Modulation to be 900 MHz spread spectrum, direct sequence, 10 channels.

4. Wireless Transmission / Encryption: AES-128 bit Key minimum.

5. Power supply required 12VDC or 24VDC.

6. Acceptable Manufacturer: Schlage Electronics PIM400 Panel Interface Module.

d) Hand Held Programming Device:

1. Capable of initializing lock and accessories using preloaded Schlage Utility Software.

2. Used to field configure devices:

a. Credential Reader Formats

b. Lock Function

c. Unlock Period

d. Power Failure Mode

e. Audible Alarm ON/OFF

f. Battery Status

g. Validate hardware and software revision

h. Troubleshooting Status Signals

i. Special Access Delay (ADA)

j. Delayed Egress (Release Delay)

k. Door Propped open Delay

l. Lockdown Cancel Delay Time Out between credential and PIM

m. Number of Key presses without valid PIN before lockout

n. Current Date/Time

o. Enable/Disable Manual Programming

3. Utilized to download firmware updates and door files to device.

4. Utilized to download audit files from device.

5. Hand Held Device to have:

a. 3.5 inch LCD display minimum

b. Touch Screen/Keypad Backlit

c. 32-bit processor minimum

d. Memory: 128MB RAM/256 MB ROM

e. Battery: Rechargeable Li-ion

6. Acceptable Manufacturers: Schlage Electronics HHD series with Schlage Utility Software
- The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.
- THE UNIVERSITY OF CHICAGO FACILITIES SERVICES
- FS² Volume III - Design Requirements | Page 119

VOLUME III – DESIGN REQUIREMENTS

I) INTERIOR FINISHES & ACCESSORIES

c-10. Electro-magnetic locks

- a. Wireless Electronic Mortise type Locksets are to meet the following criteria:
 1. Surface mounted magnetic lock shall be capable of providing a pull-apart or tensile holding force of at least 1200 pounds. Magnetic lock shall have automatic dual voltage – no field adjustment required.
 2. Securitron M62 Series is the preferred manufacturer.
 3. Locks shall operate on 24VDC input and shall not consume more than three (3) watts of power (150mA @ 24VDC).
 4. The strike plate shall be mounted using a steel sex bolt and roll pin to provide a “floating” movement to assure automatic self-alignment with the lock. Anti-tamper caps shall be provided for the exposed holes.
 5. The lock shall be full sealed to make it tamper and weather proof.
 6. The lock shall contain a suppression circuit to prevent residual magnetism and inductive kickback. The circuit also shall provide accelerated field collapse and radiation suppression.
 7. The lock shall have a universal threaded conduit fitting and ten feet of jacketed stranded conductor shall be provided for electrical connection.
 8. The lock and strike shall be plated to provide corrosion proofing.
 9. Locks shall have a lifetime replacement warranty
 10. Lock shall have available options such as magnetic bond sensor, integrated door position switch, split and offset strike plates, dress cover, wide assortment of installation brackets
 11. Hardware accessories shall include brackets, housings and dress covers.

c-11. Electromagnetic door holder/releases

- a. Electromagnetic door holder/releases are to meet the following criteria:
 - All electromagnetic door holder releases shall be supplied by the architectural hardware supplier to properly coordinate with locking devices.
 - All units shall have a single coil to accommodate 12vdc, 24vac, 24vdc and 120vac. Coils shall be independently wound employing a fuse.
 - Armatures will have a positive release button.
 1. Rixson is the preferred manufacturer.
 2. Electromagnetic door holder/releases are to be coordinated with the fire protection system and as required by code.

c-12. Overhead Stops

- a. Unless otherwise noted in Hardware Sets, provide wall type with appropriate fasteners. Where wall type cannot be used, provide overhead type.
 1. Rixson, Glynn-Johnson are the preferred manufacturers.
 2. All overhead stops and holders shall be from a single manufacturer.
 3. Standard-duty models shall be used for interior or low to medium traffic doors.
 4. Heavy-duty models shall used for exterior or high traffic doors or doors subject to abuse.
 5. For extremely abusive areas or high winds use double lever arm type.
 6. Coordinate dead-stop and/or hold open location with concealed floor closers where used.
 7. Stop, friction hold open and/or dead-stop units shall be available
 8. Units shall contain a heavy duty shock absorbing spring providing 5-7 degree compression before dead-stop.
 9. Units shall be non-handed, single or double acting and have complete mounting screws for wood or metal doors.

c-13. Thresholds

- a. Thresholds are to meet the following criteria:
 - Architectural bronze/brass thresholds shall be manufactured of CDA alloy C38500.
 - Roll Formed Aluminum Plate assemblies shall be manufactured from 5052-H32 Aluminum.
 1. Pemko, Reese, National Guard are the preferred manufacturers.
 2. Thresholds shall be available in numerous configurations and finishes for most applications, be full depth of frame and span width of opening
 3. Threshold heights shall not exceed ½” in height
 4. Weather-stripping for exterior doors shall have an aluminum housing with neoprene seals mechanically fastened with stainless steel screws.
 5. All fire doors shall have fire-rated gasketing.
 6. All sound doors shall have sound seals with STC ratings equivalent to the door assembly
 7. Exterior thresholds shall have a non-skid surface of nickel-aluminum fused to surface by exothermic reaction.
 8. Thresholds shall be beveled 1:2 maximum.

VOLUME III – DESIGN REQUIREMENTS

I) INTERIOR FINISHES & ACCESSORIES

c-14. Other Hardware and Finishes

- a. Kick Plates: Four beveled edges, .050 inches minimum thickness, height and width as scheduled. Sheet-metal screws of bronze or stainless steel to match other hardware. Where specified on the push side of accessible doors, kickplates shall be smooth, seamless, and 10” high minimum.
- b. Roller Latches: Provide roller latches for doors as scheduled.
 - 1) Projection of the roller to be easily adjusted by turning knob on back of latch.
 - 2) Projection of the roller should be up to ½” to allow for variance in the door clearance.
 - 3) Meets ANSI A156.16
- c. Seals: Specially formulated to withstand greater temperature extremes while providing maximum protection against air infiltration. UL label applied to seals on rated doors. Substitute products: certify that the products equal or exceed specified material’s thickness and durability. Proposed substitutions: submit for approval.
 - 1. Meets UL10B and ASTM E283 classification.
 - 2. Sound control openings: Use components tested as a system using nationally accepted standards by independent laboratories. Ensure that the door leafs have the necessary sealed-in-place STC ratings.
 - 3. Fire-rated Doors, Intumescent Seals: Furnished by selected door manufacturer. Furnish fire-labeled opening assembly complete and in full compliance with UL10C / UBC Standard 7-2. Where required, intumescent seals vary in requirement by door type and door manufacturer – careful coordination required.
- d. Automatic door bottoms: low operating force units. Doors with automatic door bottoms plus head and jamb seals cannot require more than two pounds operating force to open when closer is disconnected.
- e. Sweeps: Specially formulated to withstand greater temperature extremes while providing maximum protection against air infiltration. Neoprene or nylon brush type as scheduled.
- f. Panic Pulls: When specified for use with exit devices pulls shall be 1” round bar offset type with 10” center-to-center offset pulls.
- g. Pulls: Provide 1” diameter round bar stock with 8” center-to-center pulls. Provide 2- 1/2” clearance.
- h. Push Plates: Push plates shall be minimum .050” thickness brass, bronze or stainless steel as appropriate for specified finish. Plates are to be in size scheduled in Hardware Sets. Beveled four sides, and provided with fasteners appropriate for attaching to doors. Where “CFC” or “CFTP” is indicated in Hardware Sets, factory drill holes in face of push plates to accommodate deadbolt cylinder or turnpiece.
- i. Pull Plates: Where pull plates are listed in the Hardware Sets, provide half round pull, 8” center-to-center, with 2-1/2” projection, factory attached to push plate in size indicated.
- j. Push/Pull Bars: Where push/pull bars are listed in the Hardware Sets, provide 1” diameter round bar stock with 10” center-to-center offset pulls.
- k. Flush Pulls: Where flush pulls for use with mortise locks are called for in the Hardware Sets provide cast brass or bronze 4-1/4” diameter drop ring type pull, factory modified with spindle appropriate for operation of the mortise lock.
- l. Latch Guards: Where shown in Hardware Sets at out-swing single and out-swing or in- swing pairs of doors, provide stainless steel latch guard to cover latch area or gap between door and frame, or between doors in pairs. Latch guards to be thru-bolted through door, with fasteners above and below mortise lock case. Provide proper width latch guard for use with specified lock operating trim.
- m. Electromagnetic Wall Holders: Electrically controlled, fail-safe, holds door open until current is interrupted. Furnish model to hold door away from wall to allow for any trim or levers on pull side of door.
- n. Sliding/Folding Track and Hardware: Provide heavy duty extruded aluminum track in width to accommodate scheduled door opening. For sliding doors, provide track with integral aluminum fascia. Pulls for sliding doors shall be recessed flush type; for folding doors provide track manufacturer’s wood knob listed in Hardware Sets.
- o. Fasteners: Generally, exposed screws to be Phillips or Robertson drive. Pinned TORX drive at high security areas. Flat head sleeve anchors (FHSL) may be slotted drive. Sheet metal and wood screws: full-thread. Sleeve nuts: full length to prevent door compression.
- p. Silencers: Interior hollow metal frames, 3 for single doors, 2 for pairs of doors. Omit where adhesive mounted seal occurs. Leave no unfilled/uncovered pre-punched silencer holes.
- q. Finishes: Finish selections should generally be limited to, or matching, the following:
 - Satin Bronze, US10
 - Satin Chrome, US26D
 - Satin Stainless Steel, US32D
- r. Related Work: Door frames shall be prepared by the manufacturer to accept security/ access hardware and wiring. Provide ¾” conduit minimum to controllers.

I) INTERIOR FINISHES & ACCESSORIES

d. Accessory Standards Introduction

All accessories shall comply with accessibility requirements. Placement and installation of accessories including approach clearances, clear floor space, reach ranges, and protrusion limit shall comply with applicable accessibility requirements. This portion of the facility standards includes toilet room and custodial accessory requirements to be followed by the Consultant in the course of a project at the University of Chicago:

1. Toilet Partitions

- a. Provide floor-to-ceiling anchored partitions with wall reinforcement blockings, concealed overhead bracing/support, corrosion-resistant anchoring assemblies complete with threaded rods, lock washers and leveling adjustment at connection to structural support without transmitting load to finished ceiling.
- b. Panel door material options to include: metal, polymer, laminate, stone, or wood.
- c. Provide heavy-duty operating hardware and accessories, exposed fasteners of stainless steel or chrome-plated steel or brass to match hardware.
- d. Comply with all applicable accessible ADA requirements.

2. Soap Dispenser

- a. Kutol is the University’s preferred manufacturer.

3. Paper Towel Dispensers/Disposals

- a. Georgia-Pacific Cormatic automated dispenser is the University standard. Specific installations may consider other types.

4. Toilet Paper Dispensers

- a. Georgia-Pacific Compact dispenser is the University standard. Specific installations may consider other types.

5. Air hand Dryers (Preferred)

- a. Dyson Airblade is the University’s preferred manufacturer. Specific installations may consider other types, designer to consult with University.

6. Trash and Recycling Bins

- a. Typically, the University collects building trash by two means, trash and comingled recycling containers. Container types and locations are to be reviewed with the building users and Maintenance & Operations group during the course of the project.
- b. Busch Systems, Clean River/Midpoint, and Max-R recycling bins are the preferred manufacturers, sizes will vary according to building location.

7. Baby Changing Stations

- a. Koala Kare is the University’s preferred manufacturer. Specific installations may consider other types. Designer should consult with the University.
- b. Units should be constructed from high-density polyethylene, which prohibits the retention of moisture and odor. Units should contain reinforced steel rods aiming to increase unit stability, and gas shocks should be completely hidden or a safer bed retraction.
- c. Comply with all applicable accessible requirements.

J) VERTICAL TRANSPORTATION

1. INTRODUCTION

This portion of the Facility Standards includes vertical transportation requirements to be followed by the Consultant in the course of a project at the University of Chicago. The following standards apply to a variety of conditions and types of vertical transportation systems. The standards outline preliminary requirements for vertical transportation systems throughout the campus, whether the work involves a new installation or only modernization. The Consultant or Elevator Consultant will be responsible for code compliance for the design and specification of the elevator, machine room and shaft as part of the Contract Documents for the project. The Consultant or Elevator Consultant will review all variances and applications for installation or alterations for elevators. The intent of these standards to provide guidelines in developing vertical transportation systems that:

1. Provide acceptable levels of elevator service as related to the Average Interval and Handling Capacity.
2. Provide safe and convenient transport of passengers and material.
3. Provide systems that meet the highest level of accessibility for people with disabilities.
4. Incorporate specifically identified standardized part for easy maintenance and rapid repair and/or replacement.
5. Provide reliability and achieve desired lifecycle service and cost.
6. Provide for standardized vertical transportation systems and other identified equipment as chosen by the University of Chicago thereby eliminating the installation of manufacturer proprietary equipment and controls.

Non-Proprietary Design

The University does not have in-house maintenance personnel and therefore relies upon vendors to maintain the equipment. For this reason, it is **important that non-proprietary elevator control equipment be installed** and that the following be provided by the installing elevator contractor with each vertical transportation project:

- a. Diagnostic test device complete with access codes
- b. Adjusters manuals and set-up manuals for adjustment
- c. Diagnosis and troubleshooting of elevator system
- d. Performance of routine safety tests

Manufacturer of diagnostic test device shall update, reprogram, recharge, etc., device for as long as the controls remain in place. Only the following vertical transportation controllers systems shall be considered:

- a. CEC
- b. MCE
- c. GAL
- d. ECC
- e. Approved Equal (must be non-proprietary)

A “Non-proprietary” controller product is one that is regularly sold by the manufacturer to other installers and one for which the manufacturer will provide technical support to other contractors maintaining the product.

The University and Consultant shall retain the right to change or assign a controller manufacturer or product to the Contractor.

The University or the Consultant is to retain the services of a qualified Elevator Consultant to the design team during the design, bidding, construction and warranty period of any building requiring either a new vertical transportation project or the renovation of an existing vertical transportation project. The Elevator Consultant will provide the following:

1. Provide traffic analysis and theoretical design or complex use buildings.
2. Identify the type, size and capacities of proposed vertical transportation units.
3. Review all vertical transportation specifications.
4. Review shop drawings for compliance with specifications.
5. Provide PE stamped drawing and specifications.
6. Perform inspection services during any vertical transportation installation.
7. Provide copies of all documentation of review and inspection reports to the current elevator maintenance provider.
8. Attend progress meetings and conducting final inspections.
9. Perform the 12 month warranty inspection.

J) VERTICAL TRANSPORTATION

2. SYSTEM GUIDELINES

The Consultant shall use/or obtain and use the following in the design of a new vertical transportation system installation including elevators in and for building renovations and/or additions and/or for vertical transportation new installations, modernizations and upgrades.

The Consultant is to provide, including but not limited to, theoretical and/or traffic analysis for all new buildings, especially high-rise and/or complex use buildings and identify the type (i.e. traction, hydraulic), speed, size and capacities of proposed vertical transportation units. Refer to performance charts included in these standards as well.

- Elevators shall be installed in buildings that are two stories and higher. The design shall provide direct service to all floors in the building, including floors where mechanical rooms are located.
- New elevators shall be given an individual numbering identity. Elevators that have been modernized shall retain the existing number identification.

a. Traction Elevators

- Geared traction elevators shall be used for all medium-duty and heavy-duty applications that exceed 45 feet of travel or four stops and above.
- Controllers: Refer to Introduction for approved non-proprietary elevator controls
- Rise: Any elevator utilizing more than four (4) openings in line or having abnormally tall floor heights (more than 12 feet) will be reviewed for speed requirements. In the case of new installations exceeding 12 or more landings, consultant shall provide theoretical analysis to identify the need for gearless applications.
- Emergency Power: Unless specified otherwise, emergency power for one elevator in each group must be provided.
- Modernization of traction elevators: In the case of traction elevators modernization, the original design criteria will be maintained unless otherwise specified by the University and/or elevator consultant.
- See Table 3J.01 Traction Elevator Performance

Table 3J.01: TRACTION ELEVATOR PERFORMANCE (FLOOR TO FLOOR; SECONDS +/-0.2)

BRAKE TO BRAKE +
GEARED = FLOOR HEIGHT X 60 ÷ FPM + 4.4 SECONDS
GEARLESS = FLOOR HEIGHT X 60 ÷ FPM + 3.6 SECONDS

	SPEED F.P.M.	DOOR TYPE AND OPENING WIDTH								ADJUSTMENTS* PER FOOT OF TRAVEL FROM 12' - 0" STANDARD
		SIDE OPENING				CENTER OPENING				
		36"	42"	48"	54"	36"	42"	48"	54"	
GEARED RANGE	200	11.2	12.0	12.8	13.6	9.5	10.0	10.5	11.0	0.3
	250	10.8	11.6	12.5	13.3	9.2	9.7	10.2	10.7	0.25
	300	10.4	11.3	12.1	12.9	8.9	9.3	9.8	10.3	0.2
	350	10.2	11.1	11.9	12.7	8.7	9.1	9.6	10.1	0.2
	450	10.0	10.9	11.7	12.5	8.5	8.9	9.4	9.9	0.2
GEARLESS RANGE	500	9.1	10.0	10.8	11.6	7.6	8.0	8.5	9.0	0.18
	700	9.1	10.0	10.8	11.6	7.6	8.0	8.5	9.0	0.18
	800	9.1	10.0	10.8	11.6	7.6	8.0	8.5	9.0	0.18
	1000	9.1	10.0	10.8	11.6	7.6	8.0	8.5	9.0	0.18
	1200	9.1	10.0	10.8	11.6	7.6	8.0	8.5	9.0	0.18

* Values are based on 7' 0" to 7' 6" high doors. For 7' - 6" to 8' - 6" high doors, add following factor: 1/2 second for widths up to 42" 1 second for widths over 42"

** Values are based on 12' - 0" floor to floor height. Adjust using factors noted for variation from this standard.

Find rated speed in the 1st column. Select standard floor to floor performance time from box under correct door type (side opening or center opening) and clear door opening width. Adjust this time by adding factor if doors are 7' - 6" high and adding or subtracting appropriate amount per foot of travel over or under standard floor height of 12' - 0".

Note: All times are based on heavy duty, high speed, door operating equipment and optimum adjustment. On geared applications with medium speed door operators, add 1.0 second. On gearless applications, add 0.5 second for less stringent requirements.

J) VERTICAL TRANSPORTATION

7. Hoist Machine – New:
- i. Provide a Holister Whitney or approved equal worm-gear traction machine with a motor, brake, gears and demountable drive sheave mounted in proper alignment on a common bedplate. The worm shall be accurately machined from steel and provided with a single end, double race ball bearing thrust. The worm gear shall be made from a phosphor bronze rim, accurately cut, fitted and bolted to a cast iron spider. The drive sheave shall be a demountable casting from the best grade of metal with a Brinnell hardness of 215 to 230, and shall be machined with grooves, providing maximum traction with a minimum of cable and sheave wear. Provide means for lubricating the machine. The gear housing shall have a gasketed hole to inspect the gear.
 - ii. Provide machine with electro-mechanical brake. The brake shall be spring applied and electrically released. Swivel type brake shoes shall be applied to the braking surface simultaneously and with equal pressure by means of helical compression springs. Design brake electromagnet for quick release to provide smooth and gradual application of brake shoes.
 - iii. Furnish and install new hoist cables properly sized and quantity as per code.
8. Hoist Machine – Reuse & Refurbish
- i. If it is deemed the existing machine shall be refurbished and reused for modernization purposes. The machine shall be dismantled to the extent necessary in order to properly examine critical wearing surfaces.
 - ii. The gear case shall be drained of existing lubricants and flushed so as to remove all sediment. All seals, gaskets and packing shall be renewed in conjunction with re-assembly of the machine. The proper amount of fresh lubricant as specified by the OEM shall be added to the gear case. All worn bearings are to be replaced. Upon reassembly, the machines shall be sealed using proper gasket material on all surfaces. The use of silicone alone will not be accepted.

- iii. Hoist machine brake mechanisms shall be dismantled, cleaned and examined. Brake linings shall be replaced with an asbestos-free material bonded and riveted to the exiting brake shoes. Brass or composite brake plunge sleeves displaying any sign of wear shall be replaced. Metal casing, which contained oversize or eccentric holes for brake pivot pins, shall be reamed and fitted with oilite bronze bushings. Brake pivot pins shall fit their respective holes with a maximum clearance of .003”. Pivot pins, which are undersized or scored, shall be replaced with new pins machined from cold-rolled steel. Electrical insulation on the brake coil shall be renewed. Upon re-assembly, brake lift shall be set to OEM specification with spring tension adjusted to comply with Rule 1002.3d of ASME A17.1 Code.

b. Hydraulic Elevators

Hydraulic passenger elevators shall be used for light-duty applications. They shall be limited to a maximum travel of 45 feet or four stops. New and existing applications will need to be reviewed by University and Elevator Consultant.

- 1. Controllers: Refer to Section 1.0 for approved non-proprietary elevator controls. Solid- state starters shall be used in all applications.
- 2. Provide Battery Lowering Device for emergency use in the event of a main power supply failure.
- 3. Speeds: Typical car speed is 125 – 150 feet per minute. Two stop or holeless applications may use 100-125 feet per minute.
- 4. Rise: Where the building rise is more than forty (40) feet, or the elevator requires staggered openings on either end of the car, check with Elevator Consultant for possible change in equipment of different application.
- 5. Power Units: Submersible and non-submersible, non-proprietary power units are only allowed.
- 6. Control Valve: Provide Maxton and EECO control valves only. Any other valve used must have approval by the University and/or Elevator Consultant.
- 7. Hydraulic Tank: Provide internal tank heater for elevators and in all parking garages, unheated buildings, or where exposed to freezing temperatures.
- 8. Performance: See Table 3J.02 Hydraulic Elevator Performance

Well Holes, Casings & Cylinders – New Installation & Replacement

- 1. Provide and install hydraulic jack unit. Jack unit shall be the proper size to lift the gross load to the height specified. Jack shall be factory tested to ensure adequate strength and freedom from leakage. No brittle materials shall be used in the jack construction. Jack unit shall consist of the following components:
 - i. Heavy seamless steel tubing plunger accurately turned and polished.
 - ii. Stop ring shall be electrically welded to the plunger to positively prevent plunger leaving the cylinder.

J) VERTICAL TRANSPORTATION

- iii. Internal guide bearing.
 - iv. Packing or seal of suitable design and quality.
 - v. Drip ring around cylinder top.
 - vi. Cylinder made of steel pipe and provided with a pipe connection and air bleeder.
 - vii. Weld brackets to the jack cylinder for supporting the elevator on pit channels. An auxiliary safety bulkhead shall be provided in the lower end of the cylinder.
 - viii. Jack cylinder and underground piping shall be double wrapped with an approved coating designed to help protect it from electrolytic and chemical corrosion.
 - ix. Provide PVC cylinder liner to protect the cylinder from corrosion and to contain any oil in the event of a cylinder leak. Liner shall be closed end connected to the top of the jack unit
2. Piping: Provide all necessary piping for the hydraulic elevator system. Piping shall be of the size, type and weight recommended by the manufacturer and as required by Code. Protect underground piping by coating and wrapping same as specified for cylinder. Provide sound-isolating couplings for connections of piping to power unit. Support all horizontal piping with hangers spaced no more than 10 feet apart.
3. Extra Drilling: Contractor should clearly indicate in their bid the number of hours of drilling and excavation included in their bid price as part of the jack replacement. Contractor should submit with their bid the billing rate for extra drilling hours as required.
4. Contractor shall be responsible for removal of drilling spoils from hydraulic jack replacement. Spoils must be removed and disposed of per all code and regulatory guidelines. Contractor must provide University with evidence of proper disposal of spoils.

Holeless Hydraulic Elevators – New Installations

Holeless hydraulic elevators will be considered by the University and/or elevator consultant for use on a case-by-case basis as specific requirements may necessitate.

Table 3J.02: HYDRAULIC ELEVATOR PERFORMANCE (FLOOR TO FLOOR; SECONDS +/-0.5)

SPEED F.P.M.	DOOR TYPE AND OPENING WIDTH								ADJUSTMENTS* PER FOOT OF TRAVEL FROM 12' - 0" STANDARD
	SIDE OPENING				CENTER OPENING				
	36"	42"	48"	54"	36"	42"	48"	54"	
50	21.5	22.5	23.5	24.5	19.5	20.0	20.5	21.0	1.2
75	17.5	18.5	19.5	20.5	15.6	15.0	16.5	17.0	0.8
100	15.5	16.5	17.5	18.5	13.5	14.0	14.5	15.0	0.6
125	14.5	15.5	16.5	17.5	12.5	13.0	13.5	14.0	0.5
150	13.5	14.5	15.5	16.5	11.5	12.0	12.5	13.0	0.5
175	12.5	13.5	14.5	15.5	10.5	11.5	11.5	12.0	0.5
200	12.0	13.0	14.0	15.0	10.0	10.5	11.0	11.5	0.5

* Values are based on 7' 0" to 7' 6" high doors. For 7' - 6" to 8' - 6" high doors, add following factor: 1/2 second for widths up to 42" 1 second for widths over 42"

** Values are based on 12' - 0" floor to floor height. Adjust using factors noted for variation from this standard.

Find rated speed in the 1st column. Select standard floor to floor performance time from box under correct door type (side opening or center opening) and clear door opening width. Adjust this time by adding factor if doors are 7' - 6" high and adding or subtracting appropriate amount per foot of travel over or under standard floor height of 12' - 0".

c. Machine Roomless Elevators

Machine roomless elevators will be considered by the University and/ or Elevator Consultant for use on a case-by-case basis. These should be considered for low to moderate traffic installations. The ability to remain non-proprietary may be difficult.

J) VERTICAL TRANSPORTATION

3. COMPONENT GUIDELINES

- a. Pushbutton Fixtures

1. Provide vandal resistant pushbutton fixtures with tamper proof screws as manufactured by:

i. Monitor Controls, Inc.

ii. Innovation Industries, Inc.

2. Use vandal-resistant car direction indicators located on the elevator car to indicate direction of travel and visual arrows for car direction.

3. Provide arrival gongs at each elevator lobby.

4. Fire Service Operation: Elevators shall completely comply with the applicable ASME code as adopted and/or modified by local and state law. All fixtures, operations, and provision necessary for proper operation must be provided and installed.

5. Provide the Fire Service key switch at the main fire-recall lobby pushbutton.

i. Provide etched, embossed or engraved Fire Service Signage located on each hall pushbutton cover. Surface-applied signage shall be approved by University.

ii. Engrave, etch, or emboss fire service instruction on the fixture cover in accordance with ANSI A17.1a.

6. Pushbutton designation numbering shall match room numbering designation i.e. if architectural drawing call the lowest floor “Lower Level” the elevator floor designation shall not be “Basement” etc.

7. Note that all new car and hall fixtures shall be chosen by a building representative. Failure to gain approval of the owner prior to ordering fixtures may result in contractor having to reorder fixtures acceptable to the owner.
- b. Power Door Operator Equipment

1. Use only door operator equipment that includes drive operator, hangers, locks, closures, etc. as manufactured by GAL Manufacturing Corp.

2. MOVFR door operator model shall be used on all horizontal slide passenger elevators.

3. Performance: See Table 3J.03 Elevator Door Performance

Table 3J.03: ELEVATOR DOOR PERFORMANCE

DOOR OPEN AND CLOSE TIMES								
DOOR SIZE	DOOR SPEEDS							
	2.5 FPS		2.0 FPS		1.5 FPS		1.0 (CLOSING)	
	C/O	S/O	C/O	S/O	C/O	S/O	C/O	S/O
4' 6"	1.6	2.5	1.8	2.9	2.2	3.6	3.0	5.1
4' 4"	1.6	2.4	1.8	2.8	2.1	3.5	2.9	4.9
4' 2"	1.6	2.3	1.8	2.7	2.1	3.4	2.8	4.7
4' 0"	1.5	2.3	1.7	2.6	2.1	3.2	2.7	4.6
3' 8"	1.5	2.1	1.6	2.5	1.9	3.0	2.5	4.2
3' 6"	1.4	2.1	1.6	2.4	1.8	2.9	2.5	4.1
3' 4"	1.4	2.0	1.6	2.3	1.8	2.8	2.4	3.9
3' 2"	1.4	1.9	1.5	2.2	1.7	2.7	2.3	3.7
3' 0"	1.3	1.9	1.5	2.1	1.7	2.6	2.2	3.6
2' 8"	1.3	1.7	1.4	2.0	1.6	2.4	2.1	3.2
2' 6"	1.2	1.7	1.3	1.9	1.5	2.2	2.0	3.1

For 7' - 6" to 9'- 0" high doors add .5 second.

J) VERTICAL TRANSPORTATION

c. Traveling Cable Requirements

1. Provide all elevators with complete new wiring in the hoistway, pit and machine rooms adequate for the proper operation of the equipment. Conductor shall be copper. The minimum size of conductors, exclusive of those which form an integral part of control devices and/or cabinets, shall be a minimum no. 14 for lighting or power circuits and no. 18 for operating, control and signal circuits. All material used and method of installation shall conform to the NFPA National Electrical Code and/or local Building Department Code. All insulated wiring, control wiring and wiring in traveling cables shall be tag coded at their terminal in the machine room, shaft box, elevator cab junction box and push- button stations within the cab and shall agree with the submitted wiring diagrams.
2. Existing wire raceway may be reused. Where additional wire raceway is required, it shall be zinc-coated rigid steel conduit, intermediate electrical conduit, electrical metallic tubing (EMT), or metal wireways and outlet boxes except for traveling cables. Flexible metal conduit may be used for the short connections not subject to moisture, oil or embedment in concrete. Connections to the controller shall be made in a manner that minimizes transmission of vibration or noise to the building. Hoistway raceway may be in rigid steel wiring duct. Threadless fittings shall not be used with rigid galvanized steel conduit. Electrical connections to machinery shall allow for one foot of lateral motion.
3. Travelers - New traveling cables shall be provided for all elevators and designed for elevator service in accordance with the NFPA National Electrical Code and/or local Building Department Code and shall be sufficiently flexible to readily adapt to all changes in the position of the elevator cab and hang straight without twist. The cables shall be capable of bending 360 degrees with an inside radius of one (1) foot without any permanent set and without cracking of the outer covering. The open loop shall show no tendency to twist upon itself. Cables shall have a flame-retarding and moisture-resistant outer cover. Each traveling cable shall contain 10 percent (10%) spare wires and, in any event, not less than two (2) spare wires. Traveling cables shall contain shielded wires for the intercommunication system and Coaxial Cable sufficient for a CCTV system.
4. The coaxial cable shall be terminated in the elevator pit, in a separately identified box. The other end of the coax cable shall be dead ended on one of the top corners of the elevator cab. In addition a duplex GFCI outlet shall be located on the top corner of the elevator cab dedicated for camera power only.
5. Traveling cables exceeding 100 feet in length shall have steel supporting core cables and shall be suspended directly from them to relieve the conductors of strain.
6. Provide ten percent (10%) spare wires between the controller, selector, hatchway junction box and starter's panel and also provide ten percent (10%) spare wires in each traveling cable. All spares shall be properly tagged or otherwise identified with clear and indelible markings. Install beam pads as necessary to prevent chafing of traveling cables.
7. Strain boxes shall be installed not over 80 feet apart.

J) VERTICAL TRANSPORTATION**d. Elevator Equipment Room**

1. Provide proper access to the machine room areas, hoistways and pits for all elevators in accordance with the appropriate Codes.
2. Suitable storage space for tools and materials brought to the site by the Contractor. Contractor must specify at the beginning of the project the details of storage space required. Storage space requested shall be reasonable and in accordance with the projected schedule.
3. Required mechanical ventilation in the machine room(s) to maintain ambient temperature between 45 and 90 degrees Fahrenheit with relative humidity not to exceed 85% based upon scheduled heat generation, or to maintain temperature as required by equipment proposed to be installed if different. Contractor must specify environmental requirements for the proposed equipment along with their bid package.
4. Provide properly labeled, self-closing and self-locking machine room, pit, and overhead doors.
5. Telephone lines for an autodialing in-cab communication system shall be acquired by the building and terminated in the machine room. Contractor shall install wiring from unit to the phone jack in the machine room.
6. Required electrical power to the elevator system(s) shall be provided by owner. This shall include the mainline disconnect switch(es) fused and lockable in the open position, with fuses as required, and this shall also include a ground wire. Provide 120V single phase fused and lockable disconnect switch per elevator located in the machine room for elevator car lights and fans. Provide duplex GFI protected outlets in machine room and secondary spaces. Existing grounding, feeding service and distribution in the elevator machine room shall be reviewed and upgraded as per code and equipment requirements. If needed, provide auxiliary disconnects to provide a disconnect switch within the line of sight of any moving equipment.

7. Provide shunt trip operation for mainline disconnect switches in the machine room. Shunt trip shall be initiated from heat detectors located within the vicinity of the existing sprinkler heads in accordance with applicable code guidelines. Operation of the systems upon activation of any heat detector shall be according to all applicable building, fire and elevator codes.
8. Provide smoke sensing devices at elevator lobbies on each floor, machine room, and hoistway with three (3) dry contacts terminating at a properly marked terminal in the machine room. One dry contact will be for fire recall, the second for alternate floor fire return, and the third to indicate that the smoke sensor in the machine room has been initiated. Sensing devices shall be properly zoned to provide alternate floor return for fire service recall phase I.
9. Ensure that existing sprinklers in pit are no higher than 24 inches from the floor. If they are higher than 24 inches, they should be extended downward as appropriate.
10. Provide a code-approved fire extinguisher in machine room.
11. Building should identify and abate any asbestos located in the existing elevator pit or shaftway. The contractor will be required to identify other hazardous conditions with their bid that may require attention by owner.
12. Provide card reader units to be mounted in car stations by elevator contractor. Provide mounting instructions for card readers to be mounted in new car stations. Contract with security vendor to supply card reader system to whichever elevator company will wire readers after installing them in the car stations as required.
13. Provide properly guarded pit lighting of code-required intensity, illuminated light switches, GFCI outlets, and ladder as per code requirements.
14. Provide proper lighting in machine room and other machine spaces of proper intensity and guarded as per applicable code requirements.
15. Provide a microswitch on the mainline disconnect switch to signal to the controller when the disconnect switch is switched to the “OFF” position.

16. Climate Control: Maintain temperature between 50 to 90 degrees F. See IBC Chapter 30 for additional requirements if emergency power is required or provided to elevators and for machine room venting.
17. Data/Communications: Furnish two (2) telephone lines in each elevator equipment room and one (1) data line located in a standard University data/telephone jack. One line is to be used for the emergency call system to the control center and one line is to be used RMS (remote monitoring system).

e. Pit And Hoistway

1. Pit Access: Provide a metal ladder from each pit floor starting 12” above the pit floor and extending to 48” above the lowest landing floor level.
 - i. Locate the ladder at strike jamb side of hoistway when single panel or two speed doors are used.
 - ii. Where center opening doors are used, locate the ladder on the nearest side wall.
2. Sump Pit: Provide a sump pit with approved cover below normal pit grade for all elevators on all campuses.
 - i. Furnish the sump pump with integral oil sensor so that pump will not operate if hydraulic fluid is contaminating the water.
3. Fire Protection: Hoistways may be exempt from the requirements for automatic fire protection sprinkler heads in fully sprinklered buildings. Verify requirements with IBC Section 903.3.1.1.1.
4. Provide a 7” clearance between the cleat and pit wall.
5. Items unrelated to the elevator are prohibited in the hoistway or pit.

8. Fasteners: Metal fasteners z clips or “U” shaped horseshoe clip.

J) VERTICAL TRANSPORTATION

g. Emergency Power Operation

1. Emergency Power - New:
The elevator system shall be made to operate properly with the building Emergency Power system, based on the capabilities of that system and according to code requirements for sequencing and operation. The Contractor will coordinate the emergency power system with building management.
The elevator will be able to run on alternate acceleration and deceleration, speed profile when on emergency operation and have all chokes and filters installed to minimize line harmonic line distortion.
Sequencing of multiple car banks shall also be provided to match the capabilities of the building’s emergency generator system.
2. Emergency Power - Existing:
The elevator system shall be made to operate properly with an Emergency Power system, if one is added to the building in the future according to code requirements for sequencing and operation. The elevator will be able to run on alternate acceleration and deceleration, speed profile when on emergency operation and have all chokes and filters installed to minimize line harmonic line distortion.
Sequencing of multiple car banks shall also be provided to match the capabilities of the building’s emergency generator system.

h. Warranty

1. Prior to placing the elevator into service, the University and/ or Elevator Consultant will schedule a final inspection of the equipment. The final inspection will include representatives of the Elevator Contractor, the Consultant, the Contractor, and the University elevator maintenance representative.
2. The operating permit for the elevator must be issued before the elevator can be used by the General Contractor, Sub-Contractors, or University.
3. The warranty period, which includes all labor and materials, is 12 months after substantial completion.
4. Any deficiencies found shall be corrected prior to the warranty expiration, or the warranty will be extended until such deficiencies are corrected and the elevator re-inspected.

4. REFERENCES

The entire vertical transportation system, including all elevator equipment and work, shall be in accordance with the latest requirements of the American National Standard Safety Code for elevators (ANSI) and local governing authorities, as well as in compliance with the Americans with Disabilities Act (ADA). All of the work covered by the specifications, including design, clearance, construction, workmanship and quality is to be done in strict accordance with all national, state and local codes, ordinances and elevator safety orders in effect at the time a contract for this work is executed. For any discrepancies, the code shall take precedent. Compliance is not limited to any changes or amendments imposed by the appropriate authorities to all laws specified.

K) MECHANICAL SYSTEMS

1. INTRODUCTION

The following Mechanical System Standards provide requirements and guidelines for use by the Consultant in the design and construction of mechanical systems at the University of Chicago.

The purpose of this standard is to ensure that the design and installation of new and the modification of existing HVAC systems and equipment are in compliance with the applicable code and best practices for the types of spaces supported. Design consultants shall consider ANSI/ASHRAE Standard 55, ANSI/ASHRAE Standard 62.1, ANSI/ASHRAE/ASH Standard 170 and ANSI/ASHRAE Standard 188 principles and best practices to be fully incorporated in the design intent for University of Chicago projects. Air handling and air distribution systems and appurtenances are required to provide both a comfortable environment and elimination or dilution below established thresholds of potential airborne contaminants. Equipment siting such as exhaust discharges, fresh air intakes, cooling towers and diffusers, regardless of supported space type, shall be in accordance with ANSI/ASHRAE/ASHE 170 and ANSI/ASHRAE 188. In no case shall energy efficiency take precedence over occupant safety including but not limited to the elimination of any heat recovery systems that allow cross-contamination of exhaust and supply air or result in dilution systems such as filtration, mixing and air exchange rates below best practices for the space types supported. All HVAC systems and equipment shall be installed in a manner that allows for ease of maintenance and provides a pathway for major component replacement. In no case will system components requiring routine maintenance be sited in a location that requires special procedures or supplemental equipment to access.

The Consultant shall work under the guidance of the University mechanical engineer, coordinating all technical requirements, including acceptable materials and manufacturer -model for equipment and system components, with the University mechanical engineer and project team to produce a cohesive design that meets the project scope, budget and schedule. Design shall generally meet the requirements of national, state and Chicago Code and recommendations of all industry standards. All known exceptions shall be brought to the attention immediately and steps taken to resolve outstanding issues to ensure an orderly flow of design. A continuous dialogue shall be maintained so that any issues related to design and drawings can be reviewed and agreed upon. Design review will serve as confirmation of design and not issues to be addressed for the first time. The final design shall meet the approval of the University Mechanical Engineer.

The mechanical system design shall meet the following requirements:

- A. Meet the intended building and programmatic functions.
- B. Easily modified for changes without significant alterations.
- C. Durable to meet its intended life (Reference Vol II for Life Cycle Costs Analysis)
- D. Able to operate automatically with minimal attention from facilities staff.
- E. Require minimal maintenance.
- F. Energy efficient and able to recover to normal operating conditions quickly from weekend set back.

2. DESIGN REVIEWS

The purpose of the design review is for the Consultant, in working with the Owner’s team, to establish the Owner’s Project Requirement and complete the Basis of Design document along with necessary documents, drawings, and communications to agree on the final design. Once that has been agreed upon, the Consultant will, via design review submittals and meetings, demonstrate to the Owner that the team is on track to complete the design requirements. At the same time, the progress review documents will also demonstrate that the design phase contains the necessary scope, content, and details as required by the University to be issued for competitive bidding while staying within budget and schedule.

The progress review and final documents shall also include necessary information for the operation of the building. Prior to issuing design documents for University review, the architect or prime design consultant shall coordinate all building disciplinary items including architectural, structural, MEP/FP etc., and exterior and site items so that they are ready for review.

a. Required Design Reviews:
The following requirements (Table 3K.01) are for mechanical site utilities (steam, chilled water, compressed air, City water, storm sewer, sanitary sewer, gas), mechanical HVAC, plumbing, fire protection, and building automation systems. These items and the level of detail have been identified based on previous experience as representing elements that will lead to a successful project. The University realizes that each project’s delivery process will be unique and specific requirements will need to be discussed at the onset and throughout the duration of the project. Prior to issuing the submittals for each phase for owner review, all documents shall be fully coordinated among various disciplines, reviewed and signed off by the lead design firm.

K) MECHANICAL SYSTEMS

Table 3K.01 Design Review Tasks

Tasks		1st Review Submittal	2nd Review Submittal	3rd Review Submittal
1	Calculations including heating/cooling loads, Life Cycle Analysis etc.	80%	90%	99%
2	Schematic, flow, riser and network configuration diagrams with flow and line size	90%	95%	99%
3	Single line floor and roof plans: showing equipment and distribution with flow and capacities	100%	-	-
4	Double line floor and roof plans: showing equipment, components, controller and distribution with flow, capacities and size	-	80%	99%
5	Motor list: showing horsepower for all mechanical and plumbing items	90%	99%	99%
6	Equipment schedules: for all equipment with headings and known data	50% (Schedules with heading of all anticipated equipment)	80%	99%
7	All drawings properly edited: drawing index, symbols and abbreviations, drawing number system, drawing nomenclature, line weight and scale	50% (Drawing index, symbols, abbreviations)	90%	99%
8	Typical details, sections and elevations: all items applicable to the project; AHU general arrangement; piping connection to equipment; PRV station; trap piping; metering; equipment room views; piping arrangement at AHUs, reheat coils, fans coils, radiators, hot water heaters, heat exchangers etc; condensate piping gravity drain to flash tank and receiver	50%	90%	99%
9	Equipment room general arrangement with dimensions: showing all equipment, duct and piping arrangement, demonstrating suitable room size and serviceability	50%	80%	99%
10	Architectural plans and elevations: showing location and size of air intakes and exhausts; locations of mechanical and plumbing equipment, reliefs and vents; demonstrate means and path for access to all MEP items	50%	80%	99%
11	Design details of where common thermal bridges can exist	-	80%	99%
12	Civil plans showing site utilities: showing tie in point, location entering the building terminating inside the basement; path of travel, depth of bury, spacing relative to other utilities and landscape items	50%	80%	99%
13	Campus Utilities Change Authorization form	90%	95%	99%
14	Campus Excavation Authorization form	90%	95%	99%
15	Basis of Design Documentation	100%	-	-
16	Specifications: table of contents applicable to all items; applicable sections	70%	80%	99%
17	Spreadsheet of major equipment and components: showing proposed manufacturers; long lead items	80%	95%	99%

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

K) MECHANICAL SYSTEMS

3. GENERAL DESIGN REQUIREMENTS

- a. Mechanical room drawings shall have service area clearly indicated on drawings with note to maintain service area clearance space. Provide stair access to roof mounted equipment.
- b. All equipment shall be installed within building envelope, in equipment rooms.
- c. Mechanical rooms shall have walkways with 6’-0” clear space for service.
- d. Mechanical rooms shall have stair access at minimum.
- e. Means for equipment removal shall be included in building design, provide mechanical hoist as required.
- f. Location of major equipment on roof is considered unacceptable.
- g. Design systems for future flexibility. Systems shall be easily adaptable to space layout changes.
- h. Access to mechanical rooms shall be arranged such that entry does not disturb the occupants or normal functions of the building. Where applicable, service elevators shall be sized for equipment removal from machine rooms.
- i. Mechanical shafts shall be designed to allow service on each floor and shall have provisions for future duct routing.
- j. Prior to start of design, a complete design phase schedule shall be published to incorporate review period and comment resolution period. Each phase shall be complete prior to moving on to the next phase. A set of deliverables including concept presentation, calculations, contents of drawings, and specifications shall be defined and presented to Facilities Services Operation prior to start of design.
- k. The mechanical design shall be approved by the University Mechanical Engineer prior to issue for construction.
- l. Any exceptions to the above items must have prior written approval from Facilities Services Project Manager.

4. PLAN AND SPECIFICATION REQUIREMENTS

- a. Consultants shall coordinate all construction documents with other trades. Ceiling heights, structural interferences, and electrical requirements shall all be reviewed. Coordination of all disciplines shall be done during project design phase and take place within each phase of the project design schedule.
- b. All work shall be specified, specifications shall be formatted in the current CSI’s Master Specification format.
- c. Operations and Maintenance Manuals shall be submitted during construction. Manuals shall be formatted in current CSI’s Master Specification format. Reviewed O&M Manuals shall be submitted in full prior to FS Operation participation in start-up activities near the end of construction and to be coordinated with Information Resources standards.
- d. Record drawings shall be submitted as CAD files and .pdf file format.
- e. Completion of project shall include Operation and Maintenance Manuals. Consultant shall detail outline for Contractor’s submission and review with University.
- f. Plans and specifications shall include warranty and owner training. Warranty shall include materials and labor during first two years operation from substantial completion date or completion of all punch list items, whichever is later.

K) MECHANICAL SYSTEMS

5. SYSTEM DESIGN REQUIREMENTS

- a. Refer to the Building Performance Guidelines Matrix (Volume III)
- b. A Basis of Design (BOD) narrative shall be submitted at the beginning of each phase of design. The document shall identify all design assumptions and the design intent for the mechanical systems. Life Cycle Cost Analysis and estimated utility usage shall be included. The BOD will be updated throughout the design phases of the project to reflect any revisions or re-evaluations of the project.
- c. Mechanical systems shall be central air handling units with VAV box for areas with high occupancy and load fluctuation and Dedicated Outdoor Air Systems with radiant, chilled beam etc. for ordinary occupancy with relatively steady load. Finned tube convection hydronic system shall be provided for perimeter heat. Other system types will be considered, with prior approval. Considerations will be based on effectiveness, serviceability, life cycle cost, and energy efficiency.
- d. Install occupancy control and automation programming/control sequences that enable pandemic mode settings for mechanical system operations. These controls will also facilitate MBCx
- e. Building heating and cooling load shall be determined by Block load calculations and Peak Space load calculation.
- f. Outdoor and indoor design shall meet the University of Chicago's Building Performance Guideline conditions. System sizing must consider tolerance of system components as a whole. Heating systems shall be designed with redundancy.
- g. Equipment and spaces shall be selected and designed to meet sound limits for occupancy type as established in Chapter 47 of ASHRAE 2007 Handbook – HVAC Applications or latest equivalent. Design shall meet the mid range of the sound limits defined in ASHRAE.
- h. Provide sound calculations for University Engineer's review.
- i. Design shall meet the City of Chicago sound requirement at City Lot Line and shall be quieter than existing day night time sound level on the ground level.
- j. Buildings may be designed for 100 years. Therefore building system components will need to be replaced during the building life. Equipment must be capable of replacement without significant down time.
- k. The system should be capable of providing additional fresh air and modulate accordingly.
- l. Ventilation and Air Change rates shall meet ASHRAE 62.1. Designer shall review ventilation effectiveness even during minimum air flow in variable air volume systems.
- m. Supply airflow diffusers and exhaust grilles shall be located to assure that air movement goes from clean areas to less clean areas, i.e. from corridor to mop closet to prevent odors/contaminants from permeating the building.
- n. Labs shall be negatively pressurized, unless directed otherwise by owner. Classrooms and office space shall be positively pressured.
- o. Supply, return, and exhaust grilles shall be located so air will flow towards the most contaminated area of the space. Short circuiting of airflow shall be minimized between supply and return/exhaust.
- p. Design for system resilience and adaptability that may include the ability to accommodate MERV 8 prefilters and MERV 13 filters. Consider HEPA filtration in critical spaces.
- q. Consultant shall complete piping pressure drop and ductwork static pressure calculations.
- r. Provide structural support for piping details for University Engineer to review.
- s. Equipment cut sheets shall be included with DD phase review.
- t. Perimeter heating shall be incorporated in spaces with large windows.
- u. Electric heating is generally not allowed.
- v. In new building or addition design, a wind analysis shall be performed to determine the best location of ventilation intake and exhaust air locations.
- w. The campus operates 24 hrs/7days a week. Construction shall have appropriate isolation for all systems.
- x. A Computational Fluid Dynamics (CFD) model is recommended to be performed where airflow patterns are critical. Discussion with Owner shall determine where required. CFD modeling can also be used establish thermal comfort and ventilation effectiveness for non-traditional mechanical systems. Non-traditional system proposal shall be discussed with Owner prior to design.
- y. Equipment cooling with domestic water is prohibited.
- z. Avoid small fan coil units, fan powered boxes and unit heaters where possible to minimize service points. Where used, equipment shall be controlled by the BAS.
- aa. Design hydronic systems with two-way valves.
- ab. See Table 3K.02 Mechanical Design Guideline for temperature design standards.

K) MECHANICAL SYSTEMS

Figure 3K.02 MECHANICAL DESIGN GUIDELINE

Building Type	Indoor Design Temperature, Occupied °F ¹	Noise Max NC	Humidity Range Relative Humidity	Base System Type ³	Coil Design Heating Entering Water Temp.: °F	Coil Design (actual) Chilled Water Entering Temp: °F (Δ T.) ⁴	Prefilter / Final Filter Merv	Outdoor Design Temperatures °F
Academic Classrooms	72° F +/- 2°	27	As required by project	Custom AHU	140°	45° (16°)	8/13	Summer: 95°DB/78°WB Winter: -15° DB
Administration Offices	72° F +/- 2°	30	As required by project	Custom AHU	140°	45° (16°)	8/13	Summer: 95°DB/78°WB Winter: -15° DB
Research Laboratory	72° F +/- 2°	35 ²	Summer: 55 Max. Winter: 30 Min. (as required by project)	Custom AHU	140°	45° (16°)	8/13	Summer: 95°DB/78°WB Winter: -15° DB
Residential Dorms	72° F +/- 2°	30	As required by project	Fan Coil Units	140°	45° (8°)	8	Summer: 95°DB/78°WB Winter: -15° DB
Athletic	72° F +/- 2°	45	As required by project	Custom AHU	140°	45° (16°)	8/13	Summer: 95°DB/78°WB Winter: -15° DB
Assembly (theater, food service, religious)	72° F +/- 2°	35	As required by project	Custom AHU	140°	45° (16°)	8/13	Summer: 95°DB/78°WB Winter: -15° DB
Commercial	72° F +/- 2°	35 ²	As required by project	Modular AHU	140°	45° (16°)	8/13	Summer: 95°DB/78°WB Winter: -15° DB
Museum, Library	72° F +/- 2°	30	Summer: 55 Max. Winter: 40 Min. (as required by project)	Custom AHU	140°	45° (16°)	8/13	Summer: 95°DB/78°WB Winter: -15° DB
Support (shops, storage, parking garages)	80° F Summer 65° F Winter +/- 5°	45	As required by project	Modular AHU	140°	45° (16°)	8	Summer: 95°DB/78°WB Winter: -15° DB
Utility Plant (chilled water, steam plants)	80° F Summer 65° F Winter +/- 5°	< 80	As required by project	Modular AHU	140°	45° (16°)	8	Summer: 95°DB/78°WB Winter: -15° DB

- Notes:
- 1. Adjust guideline to suite individual projects per BOD/ASHREA/LEED requirements.
 - 2. Decision to connect to campus utilities should be based on feasibility, potential long term operational cost savings, and man power savings.

Footnotes:

¹ Controls shall allow for unoccupied temperature settings

² Noise not to exceed 40 dB at fume hood locations; dB to be as low as achievable.

³ Provide custom AHU up to 8,000 CFM

⁴ Actual operation can be 45° +/- 3-5°

K) MECHANICAL SYSTEMS

6. BUILDING MECHANICAL SYSTEMS SUMMARY

The University generates steam and chilled water from central utility plants and distributes via tunnels and buried piping to various buildings on campus.

a. Steam:

Steam is distributed at 175 psig and 80 psig to University buildings and at 125 psig to the Medical Center. Upon entering each building, pressure is generally stepped down via 175/80 and 80/15 pressure reducing stations. Generally, piping and components used for distribution are rated for 300# class. Valves shall be 300# rating steel body gate valves or triple offset butterfly valves. Flanged bolts shall be ASTM A193 B7 bolts, H2 nuts or SAE grade 8 bolts. This includes all piping and components leaving the central utility plant, traveling via the campus distribution piping and entering the building up to and including the first pressure reducing station. Piping and components shall be steel with welded connections or flanged connected to larger sized components. This includes the first isolation valve upon entering the building to the isolation valve downstream of the pressure reducing station and the entire condensate trap assembly. This also includes piping and components from the discharge of the building condensate receiver pump to pipe leaving the building.

Provide threaded pipe unions for connection to both sides of steam trap. Include the following requirements:

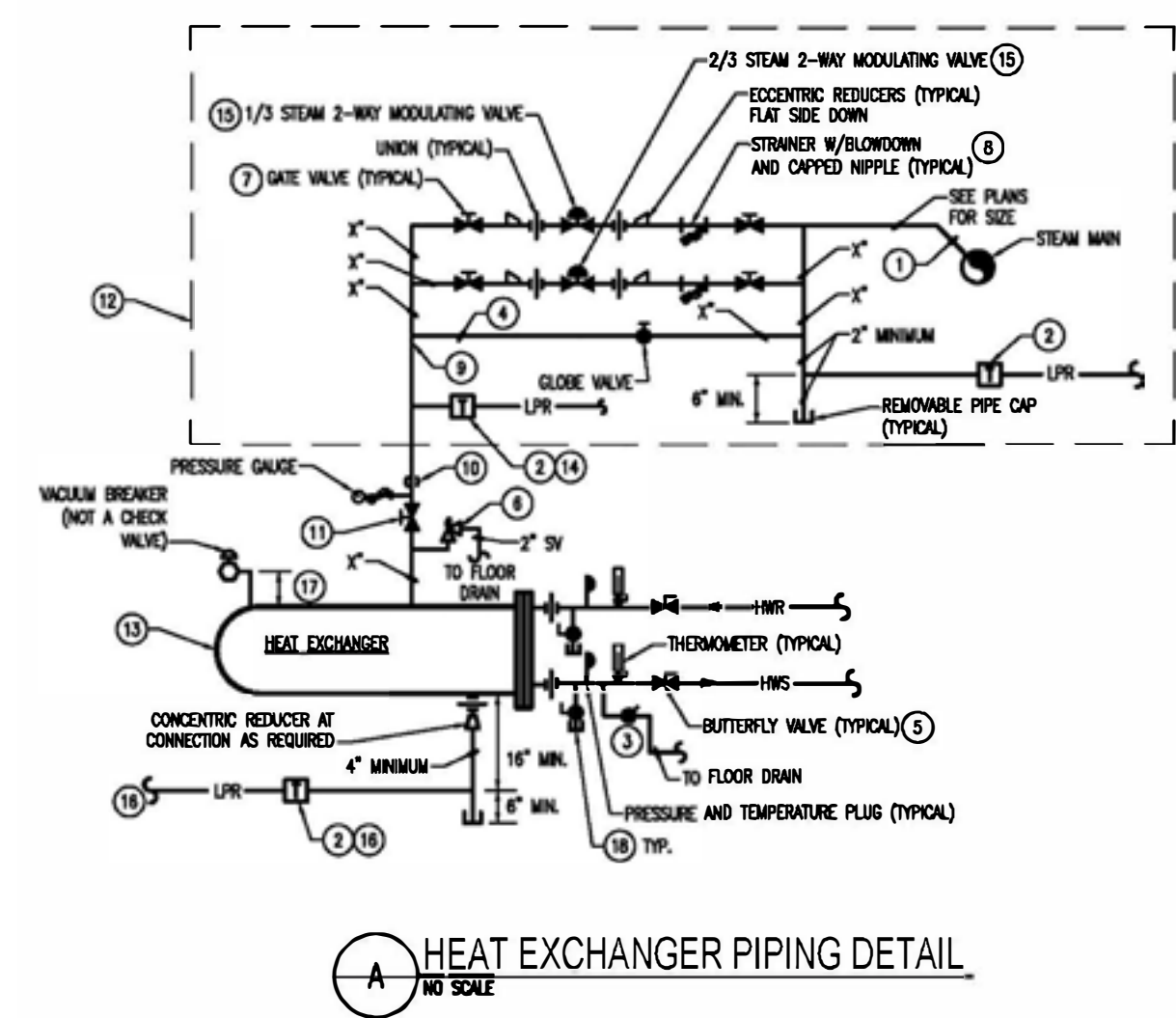
- a. Pipe anchor design for the pressure reducing station
- b. Piping flexibility analysis for new piping to the pipe anchor at the pressure reducing station
- c. Flanged bolt torqueing
- d. Safety relief calculation for valve and pipe sizing and support

See Figure 3K.03 Heat Exchanger Piping Detail.

Piping downstream of the first pressure reducing station and upstream of the building main condensate return receiver and pump shall be 150# class.

The 300# class campus distribution piping shall be hydro tested to 400 psig. The 300# class piping located inside the building shall be hydro tested to 300 psig. Piping that are 150# class shall be hydro tested to 1.5 times the operating pressure but not less than 150 psig. Test pressure shall be at a steady reading for not less than 4 hours. After that is achieved, pressure shall be reduced to the pressure class and be left overnight and check for maintaining the same reading. During the test, all joints shall be exposed for visual inspection.

Figure 3K.03 HEAT EXCHANGER PIPING DETAIL



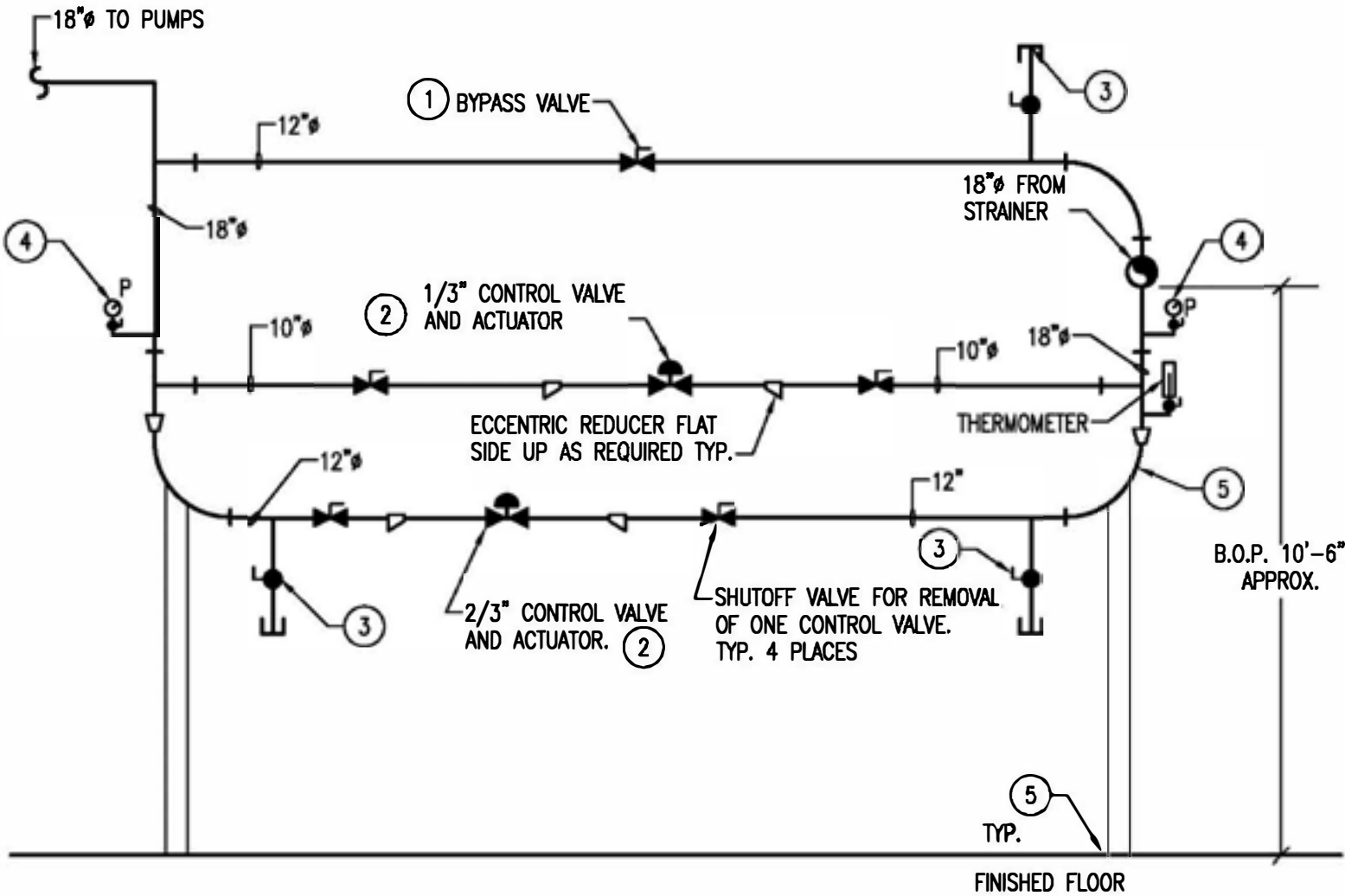
- PLAN NOTES
- 1 CONNECTION TO STEAM MAIN SHALL BE MADE FROM TOP OF HEADER OR AT A 45 TAKE-OFF IN LOW HEIGHT SITUATIONS.
 - 2 SEE STEAM TRAP DETAIL.
 - 3 WATER PRESSURE RELIEF VALVE MUST BE LOCATED WITH NO VALVE BETWEEN IT AND THE HEAT EXCHANGER. "HV" STAMPED SAFETY VALVE SHALL RELIEVE RATED BTU/HOUR AT MAXIMUM WORKING PRESSURE. PIPE DISCHARGE TO FLOOR DRAIN.
 - 4 MANUAL BY-PASS LINE
 - 5 PROVIDE BALL VALVES IN LIEU OF BUTTERFLY VALVES WHEN PIPE SIZES ARE 2" AND BELOW.
 - 6 "UV" STAMPED STEAM RELIEF VALVE MUST BE LOCATED WITH NO VALVE BETWEEN IT AND THE HEAT EXCHANGER. PIPE DISCHARGE DOWN TO 6" AFF. "UV" STAMPED SAFETY VALVE WITH RESILIENT SEAT SUITABLE FOR 250°F WITH PACKED LEVER (STEAM SERVICE ASME SEC. VIII) AND STAINLESS SPRING SIZED FOR 1200 PPH STEAM (90% RATED AT 10% OVERPRESSURE). SET TO RELIEVE AT 125 PSIG OR AS REQUIRED BY ASME CODE.
 - 7 ROTATE 45 DEGREES FROM HORIZONTAL, TYPICAL.
 - 8 STRAINER TO BE HORIZONTAL TO MINIMIZE CONDENSATE BUILDUP.
 - 9 PROVIDE LOW POINT STEAM TRAP AS REQUIRED.
 - 10 TO OTHER HEAT EXCHANGER, PIPED IDENTICAL TO THAT SHOWN.
 - 11 SHUTOFF VALVE REQUIRED FOR TWO HEAT EXCHANGERS SERVED BY THE SAME CONTROL VALVES. SHUTOFF VALVE TO BE FULL SIZE OF HEAT EXCHANGER CONNECTION.
 - 12 STEAM CONTROL VALVE STATION SHALL BE SUPPORTED ON PIPE ROLLERS. ROLLERS SHALL BE SUPPORTED BY FLOOR MOUNTED SUPPORT STRUCTURE FABRICATED FROM 4" X 4" ANGLE IRON WITH BASE PLATES GROUTED AND ANCHORED TO FLOOR.
 - 13 HEAT EXCHANGER SHALL BE SUPPORTED BY FABRICATED STRUCTURE SUITABLE FOR WEIGHTS AND LOADS. STRUCTURE BASEPLATES SHALL BE GROUTED AND ANCHORED TO FLOOR.
 - 14 TRAP IS REQUIRED IF LOW POINT EXISTS AFTER CONTROL VALVES. THIS STEAM TRAP HAS ZERO ABILITY TO LIFT CONDENSATE DUE TO MODULATING STEAM CONTROL VALVES. GRAVITY ROUTE TO CONDENSATE COOLER TO DISPOSE OF CONDENSATE.
 - 15 ROTATE CONTROL VALVES WITH ACTUATOR AT AN ANGLE OF 15 TO 45 DEGREES FROM VERTICAL AND PROVIDE A MINIMUM OF 1.5 TIMES ACTUATOR LENGTH CLEAR SPACE TO DISSASSEMBLE ACTUATOR.
 - 16 THIS STEAM TRAP HAS ZERO ABILITY TO LIFT CONDENSATE DUE TO MODULATING STEAM CONTROL VALVES. GRAVITY ROUTE TO CONDENSATE COOLER TO DISPOSE OF CONDENSATE IF CONDENSATE CANNOT BE RETURNED.
 - 17 MOUNT VACUUM BREAKER MINIMUM 6" ABOVE TOP OF SHELL OR PER MANUFACTURER'S WRITTEN INSTALLATION INSTRUCTIONS.
 - 18 3/4" LOW POINT DRAIN VALVE WITH HOSE END AND CAP.

K) MECHANICAL SYSTEMS

c. Chilled Water:

- i. Chilled water is distributed to campus buildings via underground buried piping. Pipes are generally HDPE PE4710 SDR-11 with DR9 fittings. All joints are butt fusion welded. Piping connection to isolation valves shall be flanged with factory trimmed pipe termination to allow valve disc travel. Isolation valves shall be 250# body rating with 250# bolt pattern, ductile iron body and disc, stainless steel shaft, EPDM seat, and made in USA. Flange bolts and nuts shall be stainless steel and be tightened to specified torque. HDPE piping shall be hydro tested at 200 psig for 4 hours with steady pressure reading and all joints exposed and be left overnight at 150 psig to maintain steady pressure with no leak. Re-torque bolts after 24 hours. Maintain 50 psig pressure during backfilling, following University trenching requirement.
- ii. Upon entering a building, the HDPE pipe shall be transitioned into steel pipe via a building shutoff valve with flanged or lugged connection.
- iii. Building chilled water system shall be 150# class steel pipe. Building 80 feet and taller shall have plate and frame heat exchanger isolating the building static pressure.
- iv. Chilled water bridge with metering, valves, controls, and instrumentation shall be provided near building entrance location inside a mechanical room. Piping and components in direct contact with campus chilled water shall have a higher rating than piping on the building side of the plate frame heat exchanger. On the campus side, piping 4 inch and larger shall be steel with welded connection. Piping 3 inch and smaller shall be Type K copper with brazed joints. Connection to equipment and components shall be flanged or brazed. Coils shall have .035 tube thickness. On the building side, type L copper with silver solder is allowed. Unitary equipment with thickest tube coil despite less than .035 is allowed. Threaded connection is not allowed.v. See Figure 3K.04 Building Chilled Water Control Valve Detail.

Figure 3K.04 BUILDING CHILLED WATER CONTROL VALVE DETAIL



- Notes:
- 1. Bypass valve is normally closed. Valve is opened to run off CTE District pressure differential if building pumps are inoperative.
 - 2. Rotate valve 45 degrees from vertical. Verify with manufacturer's written installation instructions for actuator.
 - 3. 3/4" valve with hose end capped.
 - 4. 6" dial pressure gauge, 0-160PSG range.
 - 5. Support from floor. Insulate first 12" of pipe support below pipe with elastomeric. Anchor support to floor and grout floor plate, see detail.

K) MECHANICAL SYSTEMS

7. CAMPUS UTILITY SYSTEM REQUIREMENTS

- a. Air Handling Systems
 - i. General
 - 1. Air Intake & Mixing: Location of intake and exhaust shall be considered during design, with regard to prevailing wind and contaminant sources to prevent entrainment of contaminants and reentering at intake of adjacent buildings and also cause nuisance to pedestrians on campus ground.
 - ii. Unit Startup Services: Units shall have factory startup services. Installing contractors shall not start or operate equipment until factory personnel provides startup service. Owner shall be notified in advance for observing factory testing.
 - iii. Industry Standards: AMCA, ARI, NEMA, UL listed, ASHRAE
 - iv. Factory testing
 - a. Leak test casing, including access doors, at 10 inch pressure. Total leakage not to exceed .5% of design air flow.
 - b. Test for deflection at 10 inch pressure not to exceed 1/360 of span at sidewall and roof of air handling unit.
 - c. Testing for performance at design air flow and static pressure and measure motor amperage and fan rpm.
 - d. Operating at design flow and static pressure, measure fan vibration at each of the three directions. Vibration velocity shall not exceed .05 in/sec at each direction.
 - e. Operating at design flow and static pressure, collect sound data for 8 bands at AHU inlet, outlet, and side. Noise level shall not exceed limit set by acoustic consultant.

- v. Custom Indoor Air Handling Units
 - a. Unit Casings & Base
 - Units shall have minimum 4” insulated double-wall construction for walls, roof, and bottom.
 - Casing shall be “no through wall” type of construction such that with 50F in the air stream and 95Fdb and 50% RH ambient environment, there shall be no condensation in the outside casing and base.
 - Limit AHU size to 40,000 cfm and below such that units can be factory built in one piece or in sections suitable for rigging, installation, and future replacement.
 - Provide sleeved penetration with cap for field installation of instruments. No drilling through casing of AHU is allowed in the field with prior approval.
 - Allow space to accommodate the future installation of BPI or UV air sanitization systems.

- vi. Doors
 - a. Provide access doors in each section for maintenance. Doors shall be a minimum of 24” wide.
 - b. Door shall have 12”x12” view window. View window shall be insulated double pane with safety wire as needed.
 - c. Doors shall have double gasket, with 2 to 3 handles and be installed to open against the pressure.
 - d. Instrument test hole with sleeve and cap shall be provided at each door.

- vii. Fans
 - a. Units shall be configured in the draw-through type arrangement.
 - b. Fans shall be selected for additional 15% airflow capacity.
 - c. All fans shall be AMCA certified and rated for intended use.
 - d. Fans shall be scheduled on the drawing. Schedule shall include the following: Equipment Tag, total flow, total

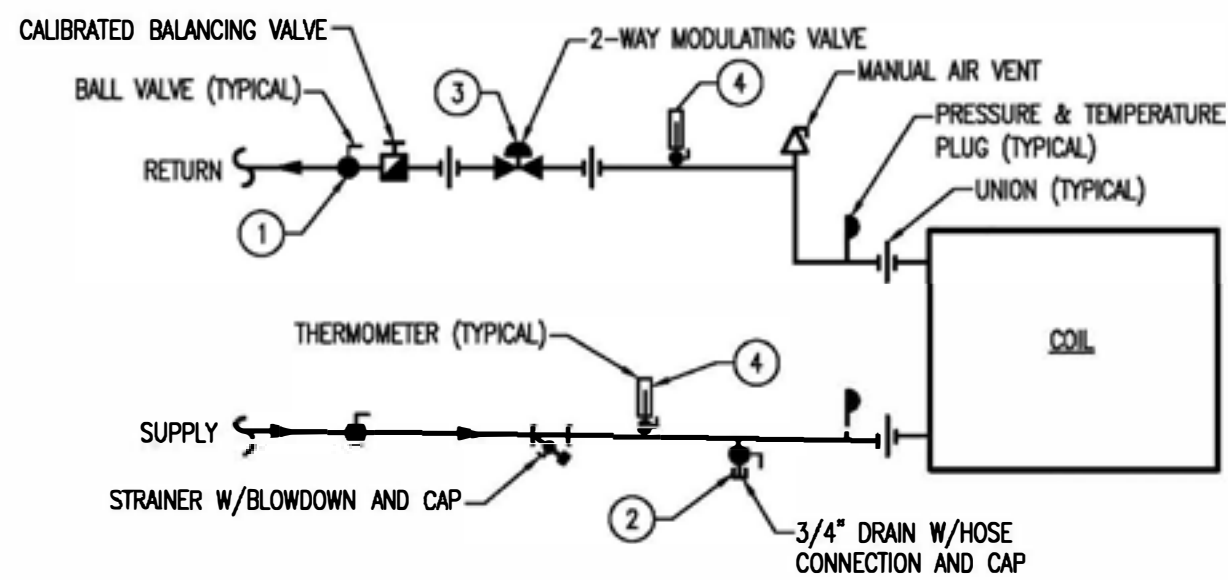
- pressure drop, fluid temperature, outlet velocity, wheel diameter, wheel type and class, arrangement, rotation, brake horsepower, motor horsepower, voltage, power phases, and manufacturer model.
- e. Fans shall be non-overloading type. Recommend backward incline or air foil type.
- f. Fans shall be arranged in an array preferably with 2 to 4 fans, direct driven type with the appropriate number of blades and built in acoustic housing to meet low noise requirement.
- g. Fans shall be provided with base, sheaves and motor directly mounted from the factory.
- h. Fan critical speed shall be a minimum of 25% greater than the fan design speed. The fan shall be statically and dynamically balanced.
- i. Fans shall have vibration isolators.
- j. Provide a VFD to control air volume.
- k. Fan bearings shall be self-aligning, pillow block or ball bearing, regreasable and shall have an average life (L10) of at least 200,000 hours. All grease fittings shall have lube lines extended for ease of service.
- l. Fan shall be coated as required for intended use. A minimum of factory primer and baked enamel finish shall be provided.
- m. Provide rail and lifting lug for removing motor out of air handling unit.

- viii. Motors
 - a. Motors shall be premium efficiency and rated for use with variable speed drives.
 - b. All motors shall be NEMA rated for intended use.
 - c. Variable Frequency Driven Motors – Induced Voltage Bearing Current Mitigation Strategies: All motors operated on variable frequency drives (VFD) shall have shaft grounding ring on the drive side and preferably insulated bearing on the non-drive side of the motor.
 - d. Motor couplings shall be selected for a service of 1.5 service factor based on motor horsepower.

K) MECHANICAL SYSTEMS

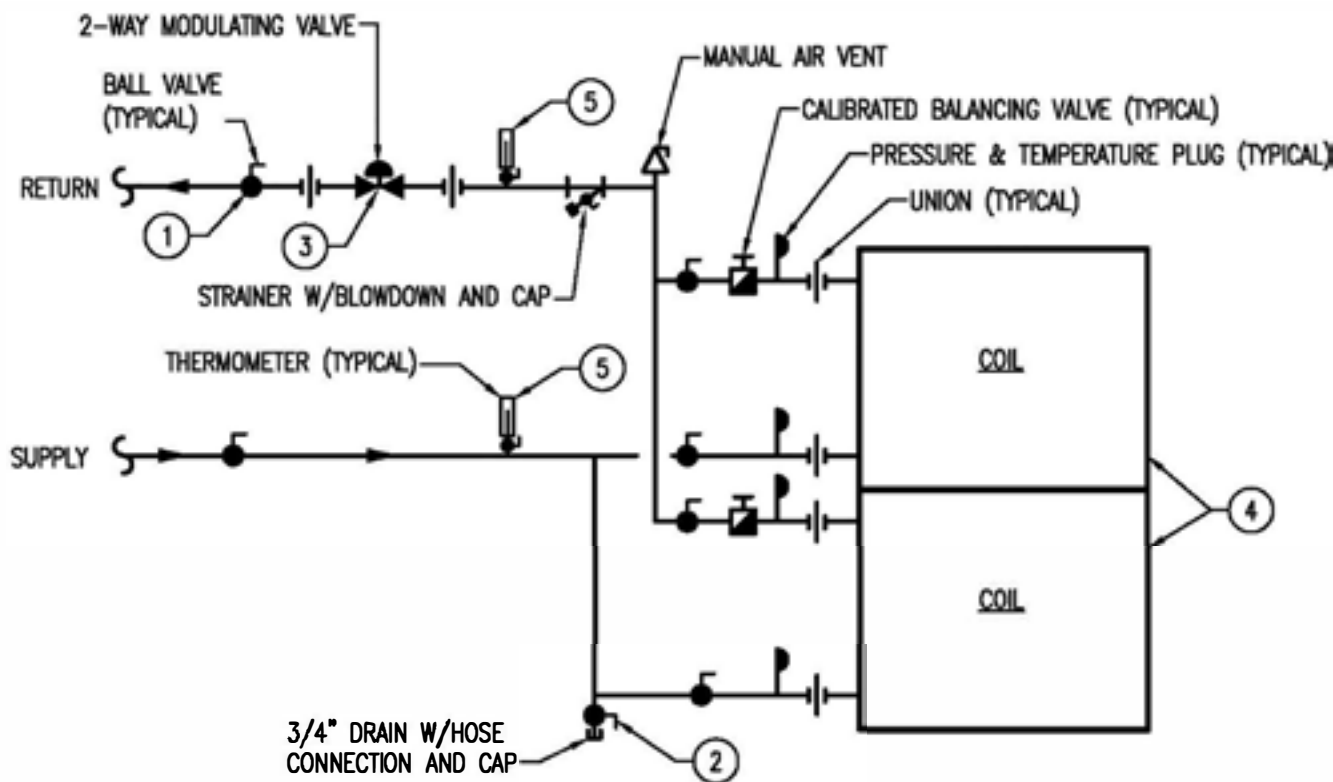
- ix. Coils
- a. All coils shall be ARI certified and pressure tested.
 - b. All coils shall be of drainable design with counter flow circuiting. (air and water)
 - c. Coil tube shall be copper and have 5/8 inch diameter, wall thickness of 0.035 inch and 0.095 inch thick aluminum fins.
 - d. Preheat coils for 100% outside air shall be designed for -15° F to 55°F. Inlet water temp of 180° and 20° or 30° rise with 30% propylene glycol.
 - e. Preheat coils for recirculated air systems shall be designed for minimum 20°F temperature rise. Glycol shall be limited to equipment rooms. Preheat coil shall be sized for outdoor design temperature when the heat recovery wheel is not in operation and also be able to deliver even air temperature across the face of the coil in the reduced operating range when the heat recovery wheel is in operation.
 - f. Chilled water coils shall be designed for 45° F entering water temperature with a 12° to 16° rise in temperature and up to 15 feet water side pressure drop. Glycol shall not be used. See Figure 3K.05 Two-Way Chilled Water Coil Piping Detail and Figure 3K.06 Two-Way Multiple Chilled Water Coil Piping Detail.
 - g. Face velocity of chilled water coils shall not exceed 450 fpm.
 - h. The designer shall schedule all coils on the drawings.
 - i. Coil assembly shall have provisions to facilitate total or partial removal from coil bank.
 - j. Provide stainless steel coil frame for cooling and heat recovery and galvanized steel frame for heating coils.
 - k. Each coil section shall have connections and valves for flushing.
 - l. See Figure 3K.07 Three-Way Heating Water Coil Piping Detail

Figure 3K.05 TWO-WAY CHILLED WATER COIL PIPING DETAIL



- Notes:
- 1. Provide butterfly valves in lieu of ball valves when pipe sizes are above 2" (typical).
 - 2. Install at lowest point in piping.
 - 3. Install modulating valve so that stem is vertical.
 - 4. Thermometers to be provided only for AHU coils.

Figure 3K.06 TWO-WAY MULTIPLE CHILLED WATER COIL PIPING DETAIL

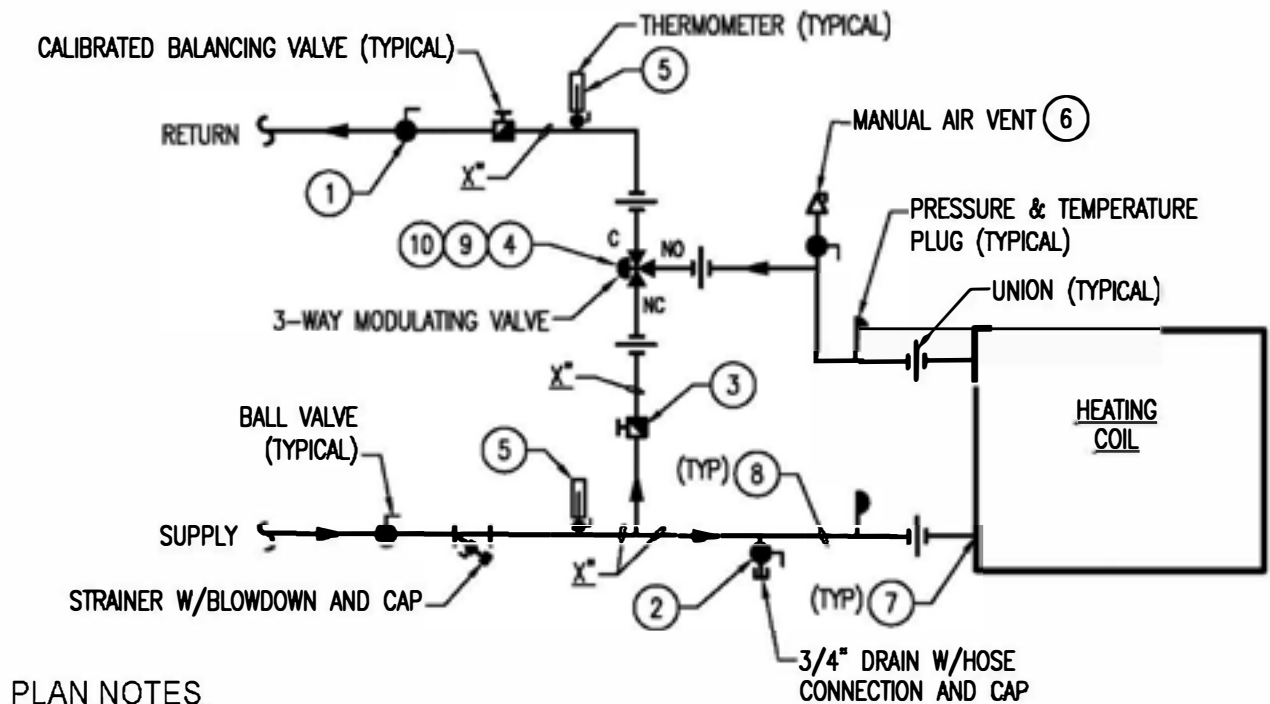


- Notes:
- 1. Provide butterfly valves in lieu of ball valves when pipe sizes are above 2" (typical).
 - 2. Install at lowest point in piping.
 - 3. Install modulating valve so that stem is vertical.
 - 4. Refer to plans and schedules for quantity of coils in coil bank. Each coil to be piped separately as shown.
 - 5. Thermometers to be provided only for AHU coils.

K) MECHANICAL SYSTEMS

- x. Drain Pans
 - a. All drain pans shall have slope in two planes to eliminate stagnant water conditions and promote positive water drainage.
 - b. All drain pans shall be insulated double walled 304 stainless steel construction.
 - c. Drain pans shall extend a minimum of 4 inches upstream and 24 inches downstream of the cooling coil.
 - d. All drain connections shall be on side of unit.
 - e. Where cooling coils are stacked, intermediate drain pans shall be provided. Intermediate drain pans shall have down-comers to the lowest drain pan constructed of type 304 stainless steel.
- xi. Dampers
 - a. All dampers shall be low leakage type with blade seals. Outside air dampers shall be insulated. Intakes shall be designed to prevent the intake of rain and snow. Linkages shall be provided for multiple damper sections.
 - b. Location for actuator installation shall be noted and be installed with base plate for mounting by others. Actuation torque shall be noted in submittals.
- xii. Lights & Outlets
 - a. Provide lights in each section with conduits wired to a common external light switch; light fixture shall be moisture proof tight utilizing energy efficient light.

Figure 3K.07 THREE-WAY HEATING WATER COIL PIPING DETAIL



PLAN NOTES

- ① PROVIDE BUTTERFLY VALVES IN LIEU OF BALL VALVES WHEN PIPE SIZES ARE ABOVE 2", (TYPICAL).
- ② INSTALL AT LOWEST POINT IN PIPING BETWEEN BYPASS AND COIL.
- ③ SET PRESSURE DROP ACROSS BYPASS CALIBRATED BALANCING VALVE TO MATCH COIL FULL FLOW PRESSURE DROP.
- ④ INSTALL MODULATING VALVE SO THAT STEM IS VERTICAL.
- ⑤ THERMOMETERS TO BE PROVIDED ONLY FOR AHU COILS.
- ⑥ INSTALL AT HIGHEST POINT IN PIPING.
- ⑦ SEAL PENETRATIONS AIRTIGHT.
- ⑧ COIL TRIM SIZE AS NOTED. REDUCE TO CONNECTION SIZE AT COIL.
- ⑨ NOTE THAT 3 WAY VALVE SHOULD BE PIPED SUCH THAT COIL RETURN IS PIPED TO NORMALLY OPEN PORT OF VALVE.
- ⑩ NC - NORMALLY CLOSED PORT
NO - NORMALLY OPEN PORT
C - COMMON
 - NOTE THAT PORT DESIGNATIONS MAY DIFFER DEPENDING ON MANUFACTURER'S DESIGN; MC TO VERIFY WITH ECC.

K) MECHANICAL SYSTEMS

- xiii. Filters
 - a. All filters shall be modular 24”x24” or 12”x24”.
 - b. Prefilters shall be MERV 8 type.
 - c. Final filters shall be MERV 13 or 14 similar to 3M 4 inch high flow and high capacity type.
 - d. Sound limitations: Fans shall be selected with the lowest sound level.
 - e. Humidifiers (if specified)
 - Humidifiers shall be low pressure steam type with insulated manifold. Humidifier shall be selected to produce the required humidification with short absorption distance.
 - Installation of primary humidifier is recommended to be prior to cooling coil. Duct installation and other installation locations shall be installed with straight section with no obstructions within absorption distance. When installed in ductwork, ductwork shall be stainless steel with a minimum of 24 inches upstream of humidifier and 24 inches past absorption distance.
 - Humidifier shall be provided with separate inverted bucket traps for steam manifold and dispersion connections. Traps shall be provided with inlet strainers.
 - Humidifier air flow switch and temperature interlock shall be provided.
 - f. Heat recovery wheel shall be installed in a rigid frame with regreasable bearing. Drive assembly shall include a durable belt and tensioner properly aligned.
- xiv. Semi-custom Air Handling Units
 - a. General requirement shall be similar to custom air handling units except that casing thickness can be 2 inch; some internal components are made by the same manufacturer. Air leakage shall not exceed 1% of design air flow. Factory testing is not required.
 - b. Use limited to 4,000 cfm or less.

- b. Exhaust Fans
 - i. General
 - a. Industry Standards
 - AMCA, NEMA, UL listed, NFPA 70, ASHRAE
 - ii. Chemical resistance material or coating is required for exhaust fans in corrosive areas, such as laboratory fume hood exhaust.
 - iii. Venturi exhaust stack fans shall be used for laboratory and fume hood exhaust.
 - iv. Exhaust fans shall be located to avoid exhaust air re-entrainment and recirculation into intake louvers.
 - v. Exhaust fans shall be located within penthouse mechanical rooms. Exhaust ductwork from discharge or positive pressure side shall be welded construction to prevent leakage into building.
 - vi. Industrial Construction Utility type exhaust fans are preferred for long lasting service.
 - vii. Belt driven centrifugal exhaust fans shall have motor coupling selected for a service factor of 1.5. For 7-1/2 HP or smaller, use adjustable pitch sheave selected at midpoint of rpm range.
For 10 HP or larger, use fixed pitch sheave. Fan drives 1 HP or large shall have 2 belts; 10 HP or larger shall have 3 belts; 50 HP or larger shall have 5 belts. Bearing shall have L10 life 200,000 hours. Provide ground shaft rings for motors with variable speed drives.
 - viii. Wind analysis shall be provided prior to locating exhaust fans to prevent re- entrainment of exhaust air to intake louvers in predominant wind directions.
 - ix. Fans shall be dynamically and statically balanced to prevent vibration. Fan shall be factory balanced not to exceed .05 in/sec vibration velocity in each of the three direction. After installation, vibration limits shall be verified.
 - x. Provide spring type isolators sized to match the weight of each individual fan.

- xi. Provide flexible connectors on inlet and discharge side of fans.
- xii. Check all units for proper performance, fan and/or motor rotation and adjust as required.

SECTION K: MECHANICAL SYSTEMS

c. Chilled Water Systems

Campus chilled water shall be used for building cooling. Cooling coils shall be sized using 45°F entering chilled water. Building with coils located 85 feet above ground shall have building system isolated with plate frame heat exchanger. Heat exchanger shall be selected for 2° approach temperature. 58°F cooling water shall be utilized for chilled beam, radiant and IT room cooling.

d. Ductwork Systems

i. General

- a. SMACNA Duct Construction Standards
- b. Identification
- c. Ductwork shall be designed to limit overall airflow energy. Use low velocity and minimal obstructions as possible to keep fan static pressure to a minimum.
- d. Ductwork systems shall be looped on floors to minimize size of ductwork and facilitate future modifications.
- e. When ductwork system serves multiple floors, provide balance damper on each floor for building balance.
- f. Ductwork installed for wet labs or other wet spaces shall be constructed of stainless steel.
- g. All ductwork shall meet SMACNA leakage class A and have leakage test. Low pressure ductwork or ductwork downstream of VAV boxes can have sealant applied after installation at all joints and corners of joints in lieu of pressure testing.
- h. Noise and vibration must meet room criteria with performance testing verification.

ii. Supply Duct

- a. All supply ductwork shall be externally insulated.
- b. High Pressure duct from air handling unit to terminal box.
 - Velocity shall not exceed 2,000 fpm.
 - Pressure Drop shall not exceed 0.2 inches per 100 feet.

iii. Low Pressure

- a. Velocity shall not exceed 1,500 fpm.
- b. Pressure Drop shall not exceed 0.08 inches per 100 feet.

iv. Exhaust Ductwork

- a. Velocity shall not exceed 1,500 fpm.
- b. Pressure Drop shall not exceed 0.08 inches per 100 feet.

v. Outside Air Ductwork

- a. Velocity shall not exceed 1,000 fpm.
- b. Pressure Drop shall not exceed 0.08 inches per 100 feet.
- c. Outside air ductwork shall be insulated.vi. Fume Hood Exhaust Ductwork
 - a. Fume hoods must past AHRAE-110 test.
 - b. Ductwork shall be constructed of corrosive resistance material.
 - c. All joints shall be welded.
 - d. Minimum metal thickness of 18 gauge.

vii. Dampers

- a. Volume Dampers
- b. Fire/Smoke Dampers

viii. Diffusers

- a. Supply air diffusers shall not be located where airflow patterns will have an adverse affect on fume hood operation.

ix. Duct lining: Internal lining of ductwork is not allowed.

x. Terminal Boxes

- a. When VAV system serves laboratories, a monitoring system shall be provided to maintain proper room pressurization.
- b. Laboratory shall have pressure monitoring controls.
- c. VAV box casing shall have all internal seams and corners caulked.

- d. All internal liners must have FSK surface and be continuous around, securely fastened with open edge taped and covered with metal.
- e. Terminal box shall have blade seals around damper, leakage not to exceed 5 cfm @ 1 inch static pressure.
- f. Shaft shall be square and bolted to damper; provide mounting plate for actuator to be fastened with bolts and nuts; flow cross type of air flow measuring station; control panel shall have cover that is removable with wing nuts; access door shall be double insulated type, with continuous gasket around the edge
- g. Terminal boxes shall be installed to allow full service to unit controls and coil removal. Orientation shall be specified.
- h. All terminal boxes shall have at least 3 feet of straight duct upstream of inlet.

xi. Chilled beams or radiant panels: with flexible copper tubing stub out of housing for external soldering between panels and to building system pipe; no mechanical pipe connection is allowed.

xii. Fan Powered Boxes

- a. Use of fan powered boxes is not allowed.

xiii. Sound Attenuators shall be used at AHU, fans, and other noise creating equipment as needed to meet project sound requirements.

xiv. Fume Hoods shall be designed and tested for 80 FPM face velocity

- a. Installation shall follow “clean room or laboratory” requirements for air changes.
- b. Energy savings design shall be incorporated for night set back options.
- c. Fume hood shall be suitable for 60 to 110 fpm face velocity.

K) MECHANICAL SYSTEMS

e. Hydronic Piping Systems

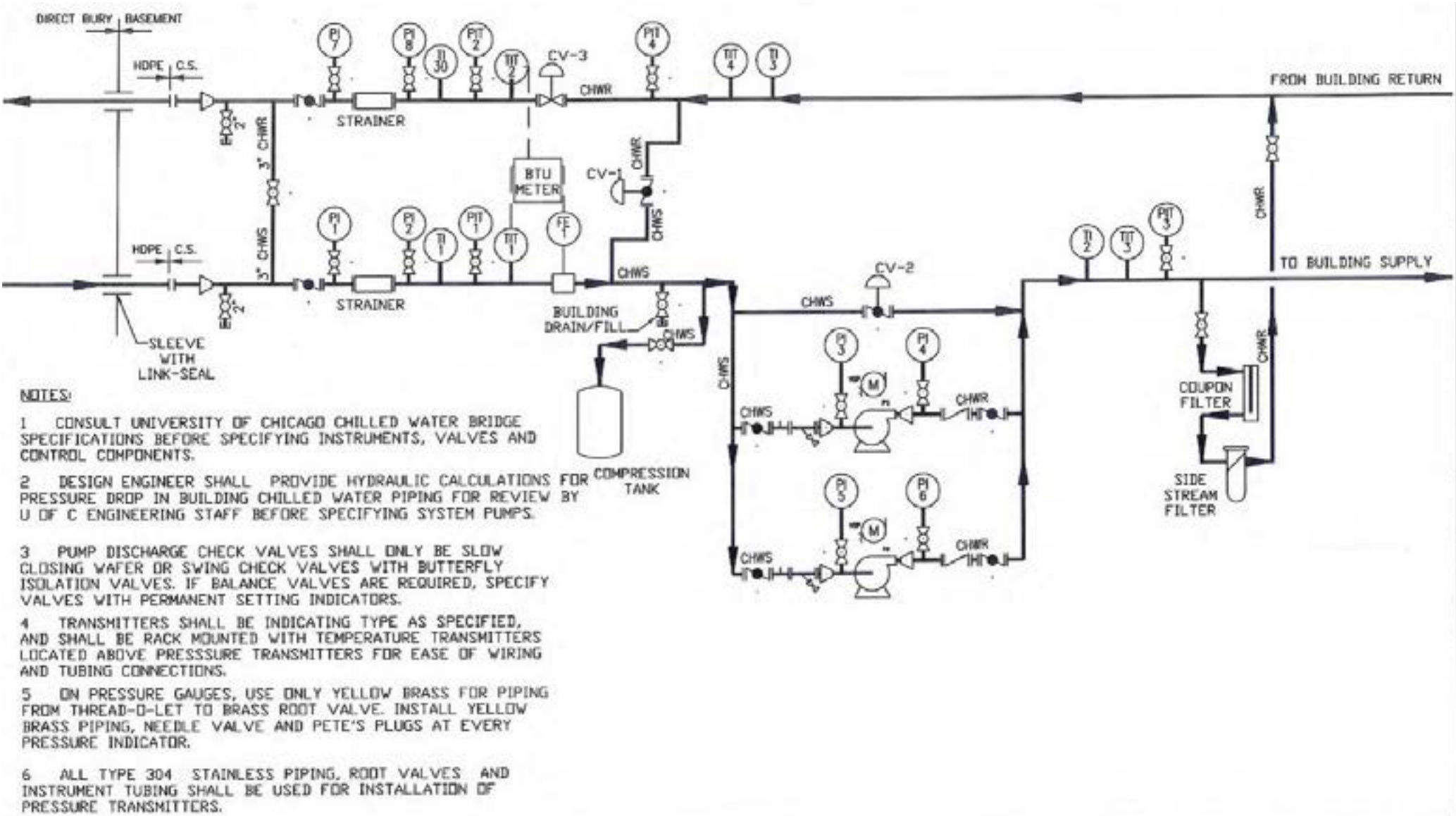
- i. General
 - a. Identification shall be labeled per University Standards. Provide color and markings on for each piping system.
 - b. Minimum pipe size shall be ¾ inches.
 - c. Triple duty valves are not allowed.
 - d. Provide check valves where required. Check valves shall be ball type.
 - e. Building hydronic heating and cooling systems subjected to pressure from campus distribution system pressure:
 - All piping accessories and components in direct contact with the campus distribution system shall be 150 psi rated.
 - Provide shut off valves at the bottom of building risers and piping takeoff on each floor. Such valves shall have the same rating as those used for building isolation.
 - f. Building hydronic heating and cooling systems not subjected to pressure from campus distribution pressure:
 - These systems include those that are isolated from campus distribution via building heat exchangers or stand-alone systems.
 - 3 inch and smaller: Copper pipe type L(if within stand alone building or isolated from campus chilled water by plate frame heat exchanger) with silver soldered joint; bass ball valve with Teflon seat. If directly connected to campus chilled water system, pipes shall be steel and welded and flanged to equipment. Use type K copper with brazed joint if connected to smaller equipment and components.
 - 4 inch and larger: Steel pipe with welded connection and flanged to equipment. Use butterfly valves with ductile iron body and disc and EPDM seat if connected to campus system; use cast iron body with bronze EPDM seat if in standalone building.
 - ii. Provide at least 3” building drain with ball valve.
 - iii. Install shutoff duty valves at each branch connection to supply and return mains, and at supply and return connection to each piece of equipment.
 - iv. Install calibrated balancing valves in the return water line of each heating or cooling element and elsewhere as required for system balancing.
 - v. Install 3 inch building drain valves and ¾ inch valve at other building low points for draining.
 - vi. Install piping at a uniform grade of 0.2%upward in direction of flow.
 - vii. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
 - viii. Install branch connections to mains using tee.
 - ix. Install strainers upstream of each control valve, pressure-reducing valve, solenoid valve, pump, and elsewhere as indicated. Install ball valve with plug at strainer for blowdown.
 - x. Install manual air vents at high points in piping with runout to drain.
 - xi. Install automatic air vents with isolation ball valve in mechanical equipment rooms only.
 - xii. Install control valves in accessible locations close to connected equipment.
 - xiii. Piping layout on floors shall be looped design to allow for future renovations or modifications.
 - xiv. Whenever possible design piping for reverse return.
 - xv. Install bypass piping with (ball or butterfly) valve around control valve. If multiple, parallel control valves are installed, only one bypass is required.
 - xvi. Install ports for pressure and temperature gauges at coil and equipment inlet and outlet connections and elsewhere as indicated.
 - xvii. Install bronze or brass valve to separate steel and copper pipes. Do not use di- electric union.
 - xviii. Chilled water usage point above 85 feet elevation from the ground shall be provided with a plate and frame heat exchanger with less than 2°F. approach for hydraulic isolation.xix.All piping components shall have steel body with 300lb rating and have welded or flanged connections. Use ASTM A193 B7 bolts, 2H nuts or SAE grade 8 bolts.
 - xx. Threaded connection is allowed in equipment room. Distribution piping throughout building shall be welded, brazed or silver soldered. No mechanical joints allowed.
 - xxi. Provide temperature and pressure wells at chilled water and heating water system components and eg coils.
 - xxii. Provide 4 inches dial gauge and temperature gauges with “plus” and ¼ inch brass connection. Use ½ inch takeoff from pipe with root valve/reaction. All span and range must work with operation range.
 - xxiii. Provide plate and frame heat exchanger for process cooling with city water as backup only.

K) MECHANICAL SYSTEMS

- f. Valves for chilled water systems
 - i. Campus distribution chilled water valves in tunnels and building basements used for isolation and in chilled water bridge on the campus side of the heat exchanger:
 - a. 3 inch and smaller:
 - 600 psig CWP rated, MSS SP-110.
 - Provide ball valves with extended quarter turn handle with steel or bronze body; blowout proof stem, chrome plated brass ball, teflon seats with bronze trim.
 - b. 4 inch and larger:
 - ASME Class 150 flanged, 200 psig CWP rated; MSS SP-67
 - Provide butterfly valves, stainless steel, or ductile iron disc; stainless steel shaft; EPDM seats; flanged or lug connection; use ASME A193 bolts and B7 nuts or grade 8 bolts with washer. For all tightening procedures use ASME B31 piping valves and fitting standards.
 - c. See Figure 3K.08 Chilled Water Bridge Diagram
 - ii. Direct buried chilled water distribution valves shall be ductile iron body and disc, EPDM seats, stainless steel shaft with body rated for 250 psi; 250 psi flanged bolt pattern for 20 inch and larger; 125 flanged bolt pattern for 16 inch and smaller; see separate details for installing valve, actuator, extension, and ground attachment.
 - iii. Isolation valves for steam and condensate for campus distribution and return in tunnels, vaults, and building basement up to and including the main PRV station and downstream of main receiver returning to to central:
 - 3 inch and smaller: Provide gate valve with 300 psi rated (800 psi for 2 inch and smaller) steel body with welded connection (flanged connection to be prior approved by the University Mechanical Engineer in a case by case basis).

- 4 inch and larger
 - Provide butterfly valve with 300 psi rated; carbon steel ASTM A216 grade WCB body with triple offset disc construction, 13% chromium hard faced, and welded connection (flanged connection to be prior approved by the University Mechanical Engineer).
 - Can also be gate valves or triple offset butterfly valves

Figure 3K.08 CHILLED WATER BRIDGE DIAGRAM



K) MECHANICAL SYSTEMS

iv. Valve Actuators

- a. Except for high temperature application such as steam and condensate systems, or systems requiring high torque for closing against operating pressure, all actuation for valves and dampers shall be electric driven with 4- 20 maDC control signal.
- b. Valves used for high temperature application such as steam systems or large size requiring high torque beyond the available rating of electric actuators, pneumatic actuators can be used. These are typically valves that are 8 inches or larger in size. Compressed air for distribution shall be regulated down to no higher than 60 psi. A current to pressure converter shall be provided so that air pressure is for valve actuation with 4 – 20 maDC control signal and having the capability of adjusting for fast acting, slow acting and also failed in last position. The building design shall include a duplex oil-less air compressor and dryer.

v. Pressure Testing

- a. Piping system shall first be assembled and erected, then pressure tested and finally blownout and cleaned.
- b. Do not install insulation or paint to piping until testing is complete. Otherwise insulation shall be removed for testing at the contractor’s expense.
- c. Lines open to atmosphere such as safety relief lines and lines downstream of the last shutoff valve need not be tested. These lines shall be visually inspected to determine that all joints are installed properly.
- d. Pressure vessels and other equipment built and tested to codes and specifications need not be tested.
- e. Preparation for Testing
 - At the time of testing, pipe metal temperature shall not be below 40°F.
 - All pipe joints shall be visually inspected for proper installation.
 - All piping systems shall be checked for adequate vent and drain connections.
- f. Pumps, compressors, heat exchangers, safety valves, flame arrestors, vessels, rupture disks, self-contained regulators, and any other equipment shall not be subjected to the

piping test pressure. The equipment shall be bypassed or disconnected, and pipe ends blind flanged or removed and a spool piece inserted in its place.

- g. When it is necessary, for practicality, to include a vessel or other equipment, the test pressure shall not exceed the allowable cold limit of the equipment. Prior approval must be obtained from the University Mechanical Engineer.
- h. Piping connected to other lines (existing lines or lines installed by others) shall be isolated or blanked off for testing.
- i. All restrictions, such as flow nozzles and orifice plates, which interfere with filling, venting or draining shall be removed from the piping.
- j. Instrumentation piping shall be tested together with the piping system up to the block valve nearest to the instrument. All instruments shall be excluded from the test by either disconnecting the piping at the instrument and capping the pipe or closing the blocking valve nearest the instrument.
- k. Automatic control valve shall be in the open position unless provided with a by-pass permitting application of pressure to both sides.
- l. Expansion joints shall be provided with temporary restraints if required for the additional pressure load under test, or they shall be isolated during the pressure test.
- m. Piping systems subject to extended hydrostatic test periods shall be provided with a protected device to relieve excess pressure due to thermal expansion.
- n. One or more calibrated indicating test gauges shall be installed in the piping to coordinate the pressuring operation. The location for test pressure gauges is at the bottom of the system for liquid service. When test gauges are installed at the top of a system, care shall be taken to ensure that over- pressuring of the piping and piping components does not occur at the bottom of the system due to the additional pressure imposed by the static head of the test media.
- o. Test pressure for campus steam and condensate distribution with 300# class pipe shall be at

approximately 400 psi.

- p. Test pressure for campus chilled water distribution using HDPE pipes shall be at 200 psi.
- q. Test pressure for building 80# steam and hydronic systems with 150# class pipe shall be at 220 psi.
- r. Test pressure for building 15# steam system shall be at approximately 125 psi.
- s. Equipment can be tested at 1.0 times the rated pressure. Therefore, after the piping pressure test, the equipment shall be connected and tested at the lower pressure.
- t. Test Procedure
 - Test procedure shall be provided for review prior to testing. Test report with sign off shall be provided after testing.
 - Test fluid shall be clean water. A suitable filter shall be provided at the fill line if sand, rust or other particles are present at the test water.
 - Another suitable fluid may be used if there is possibility of freezing.
 - Compressible fluid such as gas or air shall not be used.
 - Piping system shall be slowly filled with test fluid. All vents and other connections which serve as vent shall be open during filling, so that all air is vented prior to applying pressure.
 - Before test pressure is applied the piping must be allowed to assume approximately the same temperature as the test fluid.
 - Hydrostatic test pressure shall be 225 psig or 1.5 times maximum working pressure, whichever is greater.
 - Hydrostatic test pressure shall be maintained with no noticeable loss in pressure for a sufficient length of time to visually inspect all joints for leaks, but not less than four hours.
 - There shall be no evidence of weeping or leaking.

K) MECHANICAL SYSTEMS

- Leaks shall be marked and identified for repair. Major repairs or additions to the piping system shall be retested. Minor repairs may be waived with the permission of the University Project manager. Repairs shall be inspected and observed for leaks.
- System isolation valves shall also be tested for leaks.
- Upon completion of the test, systems shall be drained and returned to their pretest condition. All items removed, blocked-off or disassembled shall be reinstalled, reassembled, and made operative as required.

vi. Flushing of Piping

- a. General
 - Cooling water includes chilled water and cooling tower water.
 - Heating hot water includes pre-heat and re-heat hot water.
 - Piping system shall first be assembled and erected, then pressure tested and finally flushed and cleaned.
- b. Preparation for Flushing
 - Piping system shall be visually inspected for proper installation and continuity.
 - All welds are to be hammered.
 - Small equipment such as reheat coils that has restricted flow passages or areas where sediment could collect shall either be bypassed or removed and replaced by a spool piece.
 - Large equipment such as pumps, coils, and heat exchangers etc. shall have temporary strainer or basket provided by the piping contractor with galvanized woven wire cloth 0.35 mesh 6x6 installed at the inlet of each equipment.
 - All instrument lines shall be disconnected, flushed separately and then reconnected at the conclusion of the cleaning operation.
 - All low points and dirt legs shall have temporary blow-off valves installed by the piping contractor.

c. Flushing Procedure

- All pipes shall be flushed at not less than their design flow rate.
- Where possible, piping systems should be sectionalized and full system flow rates provided through individual sections.
- Strainers shall be inspected frequently during the flushing operation and cleaned if necessary. Flushing operations shall continue until all extraneous materials are no longer collected at the baskets and strainers.

vii. Chemical Cleaning of Piping

- a. Chemical cleaning shall be sub-contracted by the piping contractor to a chemical cleaning contractor pre-approved by the University.
- b. Cleaning procedures shall be prepared by the chemical cleaning contractor and submitted to the University Mechanical Engineer for review and approval.
- c. A pre-approved chemical shall be circulated within the piping system to remove grease, oil, corrosion products, mill scale, and dirt. This cleaning will provide clean surfaces for promotion of uniform protective film by corrosion inhibitors. Final concentrations, temperature, and contact time shall be determined prior to start of cleaning.
- d. After cleaning, drain the system and immediately begin the filming process to allow rapid forming of a uniform impervious film on the piping surface to stifle corrosion reaction. Fill the system with water. Inject a pre-approved chemical and circulate the solution in the piping system.
- e. Any additional steps of cleaning and filming required by the project will be performed at this time.
- f. Upon completion of flushing and cleaning operations, all temporary piping, strainers, and baskets shall be removed from the piping system unless otherwise specified. Tanks, sumps, cooling tower basins, and troughs are to be drained and thoroughly cleaned. Equipment and piping shall be returned to their pre-flush condition and permanent strainers must be cleaned.

viii. Cooling Tower Piping Flushing and Cleaning

- a. Cooling tower system must not be filled, flushed, and cleaned until chemical and biological treatment system is

planned, installed, and operable.

- b. Prior to filling the system, take pictures of tower basin, distribution deck, and vertical surfaces for project record.

ix. Requirements for Radiographic Testing of Pipes

- a. Chilled water and condenser water piping within the chiller plant shall require radiographic testing. Other piping to be tested shall be defined by the project requirements.
- b. The piping contractor that performs the pipe welding shall provide the quality of weld to pass such inspection and include all preparation work for testing. The contractor will hire the testing agency to inspect 20% of the welds. Welds to be tested shall be chosen by the University assisted by the consulting engineer. Acceptance criteria for the radiographic test shall be per ASME B 31.1 paragraph 136.4.5. If there are any failed welds identified in the first 20%, another 20% sample will be taken. If another failure is found in the 20% sample, testing of all welds will be required. The piping contractor pays for the testing of welds and all work to repair the welds.

x. Pipe Cleaning and Testing Reports

- a. Pipe cleaning and testing forms shall be provided by the contractor performing the work.
- b. The forms shall include date, project name and number, starting and ending time of cleaning and testing, related specification, test pressure, applicable system, method used, chemical used, exposure time, residual concentration, signatures and title of technician performing the test, and University representative witnessing the test.
- c. The forms shall be completed and signed immediately after the test and to be included as part of the commissioning document.
- d. The pipe cleaning and testing report shall be submitted to the University Project Manager before system startup. This report shall be part of the commissioning document.

xi. Water treatment of piping systems shall be current water treatment preferred provider.

K) MECHANICAL SYSTEMS

g. Steam Piping Systems

i. General

- a. Provide 4 inch dial with loop seal and isolation valve pressure gauges upstream and downstream of PRV station.
- b. Flanges shall be 300lb rating.
- c. Threaded connection at steam trap shall be 2,000lb rating forged steel.
- d. Note on drawings anchoring and expansion locations. Spring Loops are not allowed.
- e. Provide condensate receiver with duplex pumps or more mounted on concrete pad.
- f. Provide gauges and sight glass at condensate receiver, 4 inch dial.
- g. Provide circuit setter at condensate pump discharge.
- h. Pressure gauge upstream and downstream of condensate pump.
- i. Provide flexible connection at condensate pump discharge.
- j. All trapped condensate shall be routed to a flash tank and gravity drained into the receiver.
- k. High pressure flash tank shall have steam flashed back to lower building steam system.
- l. Lower pressure trap condensate shall be flashed to a flash tank prior to flowing back to the condensate receiver.
- m. Low pressure flash tank and receiver shall be vented directly to the roof for vent.
- n. Provide turbine type condensate meter, with discharge test port/ball valve for calibration. Provide orifice DP or vortex type transmitter to measure flow. Provide meter sizing calculation for review. Meter must be capable to measure design flow as well as low flow in the summer months with accurate and repeatable results.
- o. All piping components shall have steel body with 300lb rating and have welded or flanged connections. Use ASTM A193 B7 bolts, 2H nuts, or SAE grade 8 bolts.
- p. All piping shall be pitched in direction of flow.
- q. Flash tank shall be installed upstream of condensate

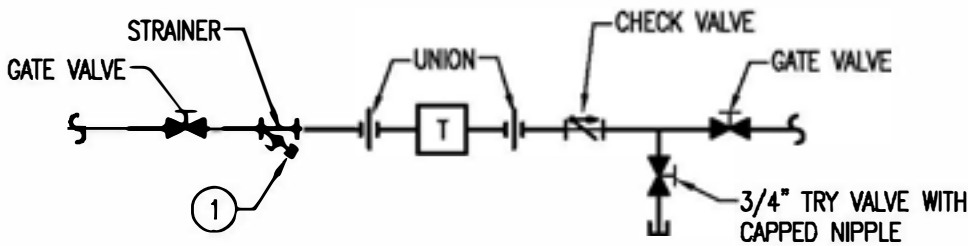
receiver, vented to atmosphere outside.

- r. Provide PRV for sizes 4” and under. Use PRV for 6” and larger. Self- regulating SRV, drip pan elbow. Provide PRV and SRV sizing and calculations for review. Provide pipe flexibility analysis for review. Show anchor guide design.

ii. Steam Traps

- a. Use only bucket traps on high pressure steam. Use F/T traps on low pressure steam.
- b. High and medium pressure traps shall be connected to flash tank prior to entering condensate receiver.
 - Flash tanks shall be vertical and not less than 18 inch diameter.
- c. See Figure 3K.09 Steam Trap Detail

Figure 3K.09 STEAM TRAP DETAIL



PLAN NOTES

- ① INSTALL 3/4” BLOW OFF VALVE ON STRAINER WITH NIPPLE AND CAP.

iii. Low Pressure Steam: Pipe shall be schedule 40 steel pipe.

iv. Clean Steam

- a. Use RO water for humidification, with carbon filtering.
- b. Humidifier shall be Dry Steam.

v. Steam Condensate shall be schedule 80 steel pipe.

vi. Installation

- a. Steam piping shall be pressure tested and flushed.
- b. Hydro test shall be 4 hours with steady pressure. Test pressure shall be approximately 1.5 times highest potential operating pressure or pipe pressure, whichever is higher. The highest potential operating pressures is the pressure that would occur in the event of a pressure reducing valve failure. Low pressure steam systems shall be hydro tested at 120 psig (80 psig operating pressure times 1-1/2). All joints shall be exposed for visual inspection.
- c. High and medium flash steam shall be recovered.
- d. Low pressure condensate and condensate from flash tank shall enter a pipe header with mechanical isolation valve prior to entering main building condensate receiver.

SECTION K: MECHANICAL SYSTEMS

h. Insulation Systems

i. General

- a. All cold or heated ductwork, piping, and equipment shall be insulated for energy efficiency and to reduce condensation sweating.
- b. Insulation material selection to be based on hot or cold application. Thermal limits of the selected material must be specified.
 - Mineral Fiber: 0°F to 1,900°F (Upper Limit)
 - Elastomeric: 0°F to 220°F (Upper Limit)
 - Calcium Silicate: 100°F to 1,200°F (Upper Limit)
- c. Selected insulation material must be formulated/treated to inhibit corrosion-under-insulation (CUI). Applicable standards include:
 - ASTM C665 – Corrosivity to steel
 - ASTM C795 Corrosion
 - ASTM C871 Corrosion
 - ASTM C692 Corrosion
 - ASTM C1617 Corrosion
- d. Selected insulation material must be formulated/treated to inhibit the growth of fungi and similar organisms.
- e. Thermal Resistance and thermal conductivity must be considered for insulating material selection and application – provide R and K-value for each specified product.
- f. Fire performance rating of insulating materials to be based on ASTM E 84, NFPA 255, and UL 723
- g. Compressive strength: Insulating material selection and specification must identify appropriate compressive resistance and be based on application, location, and installation requirements. Applicable standards include:
 - ASTM C165
 - ASTM 1621

ii. Applications

a. Equipment

- Equipment such as Storage Tanks, Air Separators, Heat Exchangers, Condensate Pumps, and Chilled water pump bodies shall be insulated.

b. Piping

- Piping shall have Mineral-Fiber with vapor barrier insulation, Flexible Elastomeric insulation, or Calcium Silicate insulation. Joints and elbows shall have protective cover jackets.
- Joints and seams shall be sealed with vapor-retarder mastic.
- Apply insulation over fittings, valves and specialties, with continuous thermal and vapor retarder integrity.
- Apply insulation continuously through hangers and around anchor attachments.
- Install insert materials and apply insulation tightly to join the insert.

c. Ductwork

- Use indoor board insulation in exposed areas such as mechanical rooms.
- Use blanket insulation in concealed areas including above the ceiling.
- Use outdoor board insulation in outdoor areas including the roof.
- Insulation shall not be installed until duct leakage testing has been performed and approved by the University project representative.

iii. Installation

- a. Provide weld pins to support insulation for rectangular ducts. Locate on sides and bottom, 12” on center starting 3” from the butt joints. Apply clip washers to pins on the surface of insulation. Cut off pins to flush with washer.
- b. Insulation shall not be compressed more than 20%.
- c. Provide 2” overlapping of vapor barrier jacketing at all longitudinal and butt joints.
- d. Cover all protrusions with additional insulation thickness.
- e. All ductwork requiring insulation shall not have ductwork in direct contact with hanger or support. Provide 6” wide 2 pound density urethane foam board inserted between duct and hanger.
- f. Apply mastic to all joints, corners, end of insulation and pins to form a continuous vapor barrier. Do not use staples or other means to break the vapor barrier.

K) MECHANICAL SYSTEMS

i. Pumps

i. General

- a. Rate pumps for system static pressure.
- b. Select pump motors to be non-overloading over the full range of the pump performance curve without utilizing any of the service factor.
- c. Select pumps for an impeller diameter not greater than 90% of the maximum pump impeller diameter.
- d. Install liquid filled pressure gage on pump suction and discharge, use single gage with multiple input selector valve.
- e. Provide non-slam silent check valve and shutoff valve at pump discharge.
- f. Provide strainer upstream of all pumps.
- g. All piping must be supported independently of the pumps.
- h. All pump to motor shaft coupling shall be aligned.

ii. In-Line, Close Coupled, Centrifugal Pumps

iii. Construction

- a. Motor pull out without disturbing piping.
- b. Stainless steel shaft.
- c. Mechanical seal with bellows and gasket. Verify components are compatible with the fluid pumped.

iv. Motors: shall be premium efficiency type.

v. Base-Mounted, Separately Coupled, Centrifugal Pumps

- a. Select end suction or double suction pumps depending on the size, application, and life cycle costing.

vi. Typical Applications

- a. Building chilled water booster pumps.
- b. Campus chilled water and condenser pumps.
- c. Building heat water system pumps.

vii. Construction

- a. Provide integral mount on volute to support the casing, and attached piping to allow removal and replacement of impeller without disconnecting piping or requiring the realignment of pump and motor shaft.

- b. Select mechanical seal on all applications except consider packing seal for abrasive fluids.
- c. Mechanical seal with bellows and gasket. Verify components are compatible with the fluid pumped.
- d. Provide EPDM coupling sleeve for all pumps.
- e. Provide vibration monitoring for large pumps. See FS Project Manager for more information.

viii. Variable Frequency Driven Motors – Induced Voltage Bearing Current Mitigation Strategies

- a. All motors operated on variable frequency drives (VFD) shall have insulated bearing on the non-drive end and a shaft grounding ring (SGR) on the drive/shaft end of the motor.
- b. All shaft grounding rings (SGR) shall be provided and installed by the motor manufacturer or contractor and shall be installed in accordance with manufacturer's recommendations.

j. Installation

i. Service Clearance

- a. Provide space around pumps for pump access and for electrical components and access required by NEC.
- b. Specify that at least one final alignment be performed in the field.
- c. Pump Pad shall be level. Pump shall be level. All bolts to be loosened to demonstrate no mechanical force at pump.
- d. Pump and motor vibrations shall not exceed .05 In/sec velocity in any of the three directions. Verification required after installation.
- e. Pump shall not operate above 60 HZ in normal operation.

k. Domestic Water Systems

- i. Domestic Hot water heater shall be of semi-instantaneous type without storage tank. Hot water recirculation for fixtures with flow rates of 1 gpm or more shall be within 20 feet of the most remote fixture. Recirculation for fixtures with flow rates less than 1 gpm shall be within 2 feet of the most remote fixture.

ii. All cold water and hot water piping including recirculation shall be insulated.

- a. All domestic water pipe shall be copper up to 6 inches. 8 inch and larger shall be cement lined ductile iron.
- b. Galvanized pipe is not allowed.

iii. Fittings:

- a. Wrought-Copper Fittings: ANSI B16.22, streamlined pattern.
- b. Galvanized Cast-iron Threaded Fittings: ANSI B16.4, Class 125, standard pattern, for threaded joints. Threads shall conform to ANSI B1.20.1.
- c. Ductile-iron Gasketed Fittings: AWWA C110, Schedule 150, with cement mortar lining and AWWA C111 rubber gaskets.
- d. Cast-iron Threaded Flanges: ANSI B16.1, Class 125; raised ground face, bolt holes spot faced.
- e. Cast Bronze Flanges: ANSI B16.24, Class 150; raised ground face, bolt holes spot faced.

iv. Pipe Applications:

- a. Install Type L, drawn copper tubing with wrought copper fittings and solder joints for 4 inch and smaller above ground, within building.
- b. Install Type K, annealed temper copper tubing for 2 inch and smaller with minimum number of joints, below ground and within slabs.
- c. Install cement-lined ductile-iron pipe with rubber gasketed joints below ground outside the building.

K) MECHANICAL SYSTEMS

1. Drainage and Vent Systems

- i. Above ground drainage and vent pipe and fittings:
 - a. Hub-and-spigot, cast-iron soil pipe and fittings:
 - Pipe and Fittings: ASTM A 74, Extra Heavy weight, cast-iron soil pipe and fittings.
 - Gaskets: ASTM C 564, rubber.
 - Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.
- ii. Underground building drain pipe and fittings:
 - a. Hub-and Spigot, cast-iron soil pipe and fittings
 - Service class Extra Heavy weight, cast-iron soil pipe and fittings.
 - Calking Materials: pure lead and oakum or hemp fiber.
- iii. Installation:
 - a. Horizontal pipe and fittings 5 inches and larger must be suitably braced to prevent horizontal movement, at every branch opening or change of direction by use of braces, blocks, rodding, or other approved method, to prevent movement or joint separation.
 - b. All drain and vent piping shall be tested to 10 feet water column applied to highest point for 4 hours with no leaks.

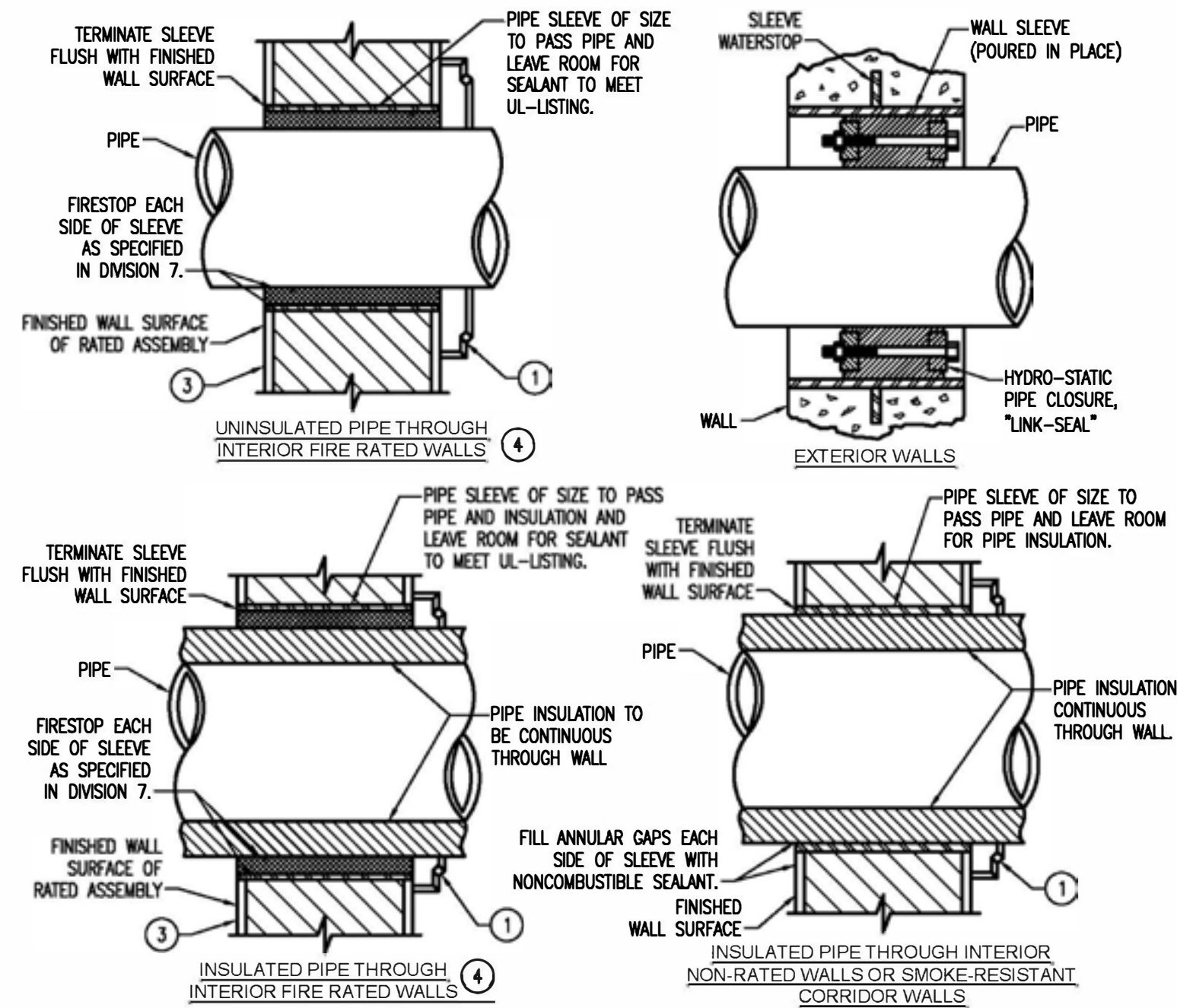
m. Plumbing Fixtures

- i. Follow water consumption guidelines set forth in Volume III. C. Sustainability section regarding use of dual-flush, low flow fixtures where feasible.
- ii. Automatic Flush valves: Sensor operated, battery powered by water flow turbine with back-up manual actuation.
- iii. Faucets: Sensor operated, battery powered by water flow turbine at public installations.

n. General Piping

See Figure 3K.10 Pipe Penetration Details

Figure 3K.10 PIPE PENETRATION DETAILS



PLAN NOTES

- ① PROVIDE ESCUTCHEON PLATE FLUSH AGAINST WALL AND OF SIZE TO COMPLETELY COVER OPENING IN EXPOSED AREAS ONLY.
- ② SEE SPECIFICATION SECTIONS FOR FURTHER REQUIREMENTS INCLUDING FLOOR SLEEVES.
- ③ LOCATE FIRESTOP LABEL ON EACH SIDE OF PENETRATION SO THAT IT IS VISIBLE FROM AN ACCESSIBLE LOCATION ABOVE CEILING.
- ④ INCLUDES FIRE WALLS, FIRE BARRIERS, SMOKE BARRIERS, AND FIRE PARTITIONS.

L) BUILDING AUTOMATION SYSTEMS (BAS)

1. INTRODUCTION

The following Building Automation System (BAS) Standards provide requirements and guidelines for use by the Consultant in the design and construction of Building Automation Systems at the University of Chicago. These systems are comprised of three primary functions: environmental control, utilities metering and lighting.

a. General Design Requirements

1. Design shall be a fully integrated Building Automation System (BAS), incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities.
2. Scope of BAS systems shall meet Owner’s Project Requirements.
3. Design of all mechanical and electrical systems, including all BAS systems (HVAC, utility/sub metering, interior/exterior lighting). The University BAS Manager is to review and approve all BAS systems designs.
4. An accepted/approved sequence of operations shall be completed for all HVAC systems. The University BAS Manager is to be consulted and have approved of all final BAS systems designs, including a BAS commissioning plan sign off.
5. Once final BAS scope is defined, the RFP shall be reviewed and approved by the University BAS Manager before going out for bids. BAS manager will review all bids and assist selecting the proper controls vendor.
6. Complete temperature control system to be DDC with electric actuation.
7. Design systems for future flexibility.
8. Prior to start of design, a complete design phase schedule shall be published to incorporate review period and comment resolution period. Each phase shall be complete prior to moving on to the next phase. A set of deliverable including concept presentation, calculations, contents of drawings and specifications shall be defined and presented to the University BAS Manager prior to start of design.
9. The BAS system design shall be approved by the University BAS Manager prior to issue for construction.

10. Any exceptions to the above items must have prio written approval from Facilities Services Project BAS Manager.

b. Plan and Specification Requirements

1. Consultants shall coordinate all construction documents with other related disciplines. Coordination of all disciplines items shall be done during project design phase and take place within each phase of the project design schedule.
2. All work shall be specified; specifications shall be formatted in the current CSI Master Specification format.
3. All drawings shall be produced using Computer Aided Drafting software, such as AutoCad or Revit.
4. Operations and Maintenance Manuals shall be submitted during construction. Manuals shall be formatted in current CSI Master Specification format. Reviewed O&M Manualshall be submitted in full prior to FS Operation participation in start-up activities near the end of construction and to be coordinated with Information Resources standards.
5. Record drawings shall be submitted as CAD files and .pdf file format.
6. Completion of project shall include Operation and Maintenance (O&M) Manuals. Consultant shall outline requirements for Contractor’s submission and review with the University.
7. Plans and specifications shall include warranty and owner training. Warranty shall include materials and labor during first two years operation from substantial completion date or completion of all punch list items, whichever is later.

c. Energy Conservation Requirements

1. All new mechanical systems shall be designed to conserve energy and shall conform to the University’s Energy PolicyGuidelines. Forms of energy recovery or conservation shall beinvestigated to maximize energy efficiency on each project.
2. Proposed systems shall meet or exceed the requirements set forth in the City of Chicago’s Energy Conservation Code.
3. Refer to Volume III., K. Mechanical Systems
4. Night set back schedules for space unoccupied times shall be incorporated into design.
5. Demand control ventilation shall be incorporated unless specifically demonstrated not to be feasible.
6. Design systems for spaces that need 24 hours per day operations separate from spaces that can utilize night set back. Example, data centers shall be design separate from the building HVAC system.
7. All incoming utilities shall be metered.

d. System Design Requirements

1. Refer to the Building Design Criteria Matrix for specific building type requirements.
2. A Basis of Design (BOD) narrative shall be submitted at the end of SD phase of design. The document shall identify all design assumptions and the design intent for the mechanical systems. The narrative may include schematic drawings and diagrams to convey the intent. Life Cycle Cost Analysis and estimated utility usage shall be included. The BOD will be updated throughout the design phases of the project to reflect any revisions or re-evaluations of the project.
3. Design shall meet the most stringent of the Chicago Code, ASHRAE, or University of Chicago’s Building Design Criteria Matrix conditions and shall meet latest the most stringent ASHRAE’s standard 55 Thermal Environmental Conditions for occupant comfort zone or University of Chicago’s Matrix temperatures. System sizing must consider tolerance of system components as a whole.
4. The campus operates 24 hrs/7days a week. Construction shall have appropriate isolation for all systems.

L) BUILDING AUTOMATION SYSTEMS (BAS)

2. SYSTEM GUIDELINES

a. Building Automation System (BAS)

- 1. System to be a fully integrated Building Automation System (BAS), incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified.
- 2. Complete temperature control system to be DDC with electric actuation as specified herein.
- 3. All wiring, conduit, panels, and accessories for a complete operational system.
- 4. BAS Contractor shall be responsible for all electrical work associated with the BAS.
 - a. Perform all wiring in accordance with all local and national codes.
 - b. Install all line voltage wiring, concealed or exposed, in conduit in accordance with the division 26 specifications, NEC and local building code.
 - c. Provide a maximum of 50 feet extension of 120 volt, 20 amp circuits and circuit breakers from Emergency power panels for all BAS equipment power. All control panels shall be wired to building central UPS systems. If no central UPS system is provided, a UPS shall be provided for each Supervisory Controller and each Application Controller deemed to be serving a critical system or function. The UPS should be installed with a network card and an automatic bypass.
 - d. Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Controllers and operator's workstations.
 - e. All low voltage electrical control wiring throughout the building whether exposed or concealed shall be run in conduit in accordance with the division 26 specifications, local building code and the NEC.

- f. Provide all miscellaneous field device mounting and interconnecting wiring for all mechanical, electrical, and plumbing systems including fuel oil system, emergency generators, chillers, boilers, heat exchangers, water treatment, AC units, condensing units, expansion tanks, VFDs, unit heaters, filtration systems, terminal units, fan coil units, electric heaters, chiller control system, boiler control system, sump pumps, sewage ejector pumps, utility meters and submeters.
 - g. All systems requiring interlock wiring shall be hardwired interlocked and shall not rely on the BAS to operate (e.g. emergency generator to fuel oil pump interlock, emergency generator damper interlock, etc.) Interlock wiring shall be run in separate conduits from BAS associated wiring.
 - h. All wells for water flow metering/monitoring devices, temperature and pressure sensors, flow switches and alarms, as required.
 - i. All installation kits for fluid flow meters, allow service and removal under pressure.
5. Provide open communications system. The system shall be an open architecture with the capabilities to support a multi-vendor environment. To accomplish this effectively, system shall be capable of utilizing industry-standard protocols as follows as well as be able to integrate third-party systems via existing vendor protocols.
- a. System shall be capable of high speed Ethernet communication using BACnet/IP and TCP/IP protocol for supervisory-level network and BACnet MS/TP for field-level network.
 - b. System shall be capable of BACnet communication according to ANSI/ASHRAE 135-2004.
 - c. System shall be capable of OPC server communications according to OPC Data Access 2.0 and Alarms and Events 1.0.
 - d. All supervisory and field-level controllers shall be BACnet Testing Laboratory (BTL) certified and listed under the appropriate device profile.

- e. The system shall be capable of supporting both industry-standard and vendor specific protocols to integrate a wide variety of third-party devices and legacy systems.
 - f. All operator interface computer hardware and standard peripherals are to be furnished by the University's ITS Department. If, for any reason, this hardware is furnished by the BAS Contractor, it shall match the University's ITS Department standards exactly and utilize ITS standard images.
6. Provide hardware, software, and wiring to provide communication interfaces with each of the systems listed below.
- a. UPS System
 - b. PDUs and Static Transfer
 - c. ATS Switches
 - d. Computer Room Air Conditioning (CRAC)
 - e. Emergency Generators
 - f. Lighting Control System
 - g. Closed Circuit TV
7. Provide system graphics for each controlled device and/or integrated systems as required by the owner. Origin of information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the BAS.
8. System should be web based with the user interface software – including graphics - imbedded in each Building Controller. All computers connected physically or virtually to the BAS network shall have access to the web based user interface.

L) BUILDING AUTOMATION SYSTEMS (BAS)

9. Primary DDC panels as follows:
- a. Minimum one (1) BAS system Advanced Application Controller (AAC) panel per each major mechanical system:
 - i. Air Handling Unit
 - ii. Hot Water heat Exchangers and associated pumps
 - iii. Chillers and associated pumps
 - iv. Cooling Towers associated pumps
 - v. Emergency Generator
 - vi. Fuel Oil System
 - b. It shall be acceptable to combine up to three (3) of the following mechanical equipment into one (1) Advanced Application Controller (AAC) panel:
 - i. Exhaust Fans
 - ii. Standalone Supply Fans
 - iii. Package AC Units
 - c. It is acceptable to wire the following systems into any of the Advanced Application Controller (AAC) panels:
 - i. Miscellaneous alarm monitoring (i.e. ATS, leak, temperature, light ...etc.)
 - ii. Miscellaneous equipment (i.e. Unit Heater, Domestic Water Heater, Standalone Dampers ...etc.)
 - d. Motors in motor control centers shall be controlled from the DDC controller associated with HVAC system. It shall not be acceptable to control all motors in a MCC from one DDC controller dedicated to the MCC. The intent of this specification is that the loss of any one DDC controller shall not affect the operation of other HVAC systems, only for the points connected to the DDC controller.
10. Stand-alone Application Specific Controllers (ASCs) for terminal equipment (CAV, FP VAV, and VAV units, and fan coil units).
11. Approved Control System Contractors and Managers
- a. The BAS system shall be furnished, engineered, and installed by one of the factory- authorized branch office of the following approved Control System Contractors

- and Manufacturers:
- i. Johnson Controls, Inc.
 - ii. Siemens Building Technologies, Inc.
 - b. Any deviations from the above list must be reviewed and approved by the University's BAS Department Manager.
12. Quality Assurance
- a. The BAS system shall be designed and installed, commissioned and serviced by factory trained personnel. BAS contractor shall have an in-place support facility within 100 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment. The BAS contractor shall provide full time, on site, experienced project manager for this work, responsible for direct supervision of the design, installation, start up and commissioning of the BAS. The Bidder shall be regularly engaged in the installation and maintenance of BAS systems and shall have a minimum of ten (10) years of demonstrated technical expertise and experience in the installation and maintenance of BMS systems similar in size and complexity to this project.
 - b. The BAS contractor shall maintain a service organization consisting of factory trained service personnel and provide a list of 10 projects, similar in size and scope to this project, completed within the last five years.
 - c. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.
 - d. All BAS peer-to-peer building controllers and local user displays shall be UL Listed under Standard UL 916, category PAZX; Standard ULC C100, category UUKL7; and under Standard UL 864, categories UUKL, UDTZ, and QVAX and be so listed at the time of bid. All field level controllers shall comply, at a minimum, with UL Standard UL 916 category PAZX; and be so listed at the time of Bid.
 - e. The BAS peer-to-peer network controllers and local user display shall also comply with the European Electromagnetic Compatibility (EMC) Framework, and bear the C-Tic Mark to show compliance. The purpose of the regulation is to

- minimize electromagnetic interference between electronic products, which may diminish the performance of electrical products or disrupt essential communications.
- f. DDC peer-to-peer controllers shall be compliant with the European EMC Directive, Standards EN 50081-2 and EN 50082-2, at the Industrial Levels. Additionally the equipment shall be compliant with the European LVD Directive and bear the CE mark in order to show compliance to both directives.
 - g. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.
 - h. The manufacturer of the building automation system shall provide documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing) and ISO-140001 (The application of well-accepted business management principles to the environment). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.
13. Codes and Standards
- a. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the design shall comply with current editions of the following codes:
 - 1. National Electric Code (NEC), latest edition
 - 2. ANSI/ASHRAE Standard 135- 2010, BACnet--A Data Communication Protocol for Building Automation and Control Networks
 - 3. City of Chicago Building Code, latest edition

L) BUILDING AUTOMATION SYSTEMS (BAS)

b. Equipment

- 1. Materials: All products used in this project installation shall be new and currently manufactured and shall have been applied in similar installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner or Owner's representative. Spare parts shall be available for at least five years after completion of this contract.
- 2. Communication:
 - a. The design of the BAS shall support networking of operator workstations and Building Controllers. The network architecture shall consist of two levels, an Ethernet-based primary network for all operator workstations, servers, and Building DDC controllers along with secondary Field Level Networks (FLN) for terminal equipment application specific controllers.
 - b. Access to system data shall not be restricted by the hardware configuration of the BAS system. The hardware configuration of the BAS network shall be totally transparent to the user when accessing data or developing control programs.
 - c. Operator Workstation Communication:
 - i. All color graphic operator workstations shall reside on the Ethernet network and the consoles shall be set up in a client/server configuration.
 - ii. The servers will act as the central database for system graphics and databases to provide consistency throughout all system workstations.
 - iii. The network shall allow concurrent use of multiple BAS software site licenses.
 - iv. Provide two (2) identical servers and a shared hard disk drive array. The second "back-up" server shall function as a hot standby back-up and automatically and immediately take over as the system server on a failure of the primary server. Each server shall be an enterprise level fault tolerant server with redundant processors. Servers shall be located on different floors to maximize redundancy. Server consoles shall not be used as operator workstations.

d. Management Level Network Communication (MLN)

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

- xi. Client access to client-server workstation configurations over the Internet network shall be available via Web browser interface.
- xii. Thin Client access to client-server workstation configurations via Windows Terminal Services shall provide multiple, independent sessions of the workstations software. Terminal Services clients shall have full functionality, without the need to install the workstation software on the local hard drive.

L) BUILDING AUTOMATION SYSTEMS (BAS)

- e. Primary Network - Panel to Panel Communication:
 - i. All Building Controllers shall directly reside on the primary BACnet/IP Ethernet network such that communications may be executed directly between Building Controllers, directly between server and Building Controllers on a peer-to-peer basis.
 - ii. Systems that operate via polled response or other types of protocols that rely on a central processor, file server, or similar device to manage panel- to-panel or device-to-device communications shall not be acceptable.
 - iii. All operator interfaces shall have the ability to access all point status and application report data or execute control functions for any and all other devices. Access to data shall be based upon logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access to the network data.
 - iv. The primary network shall use BACnet/IP over Ethernet. All devices must:
 - 1. Auto-sense 10/100 Mbps networks.
 - 2. Receive an IP Address from a Dynamic Host Configuration Protocol (DHCP) Server or be configured with a Fixed IP Address.
 - 3. Resolve Name to IP Addresses for devices using a Domain Name Service (DNS) Server on the Ethernet network.
 - 4. Allow MMI access to an individual Primary Network Controller using industry standard Telnet software to view and edit entire Primary Network.
- v. The primary network shall provide the following minimum performance:
 - 1. Provide high-speed data transfer rates for alarm reporting, report generation from multiple controllers and upload/download efficiency between network devices. System performance shall insure that an alarm occurring at any Building Controller is displayed at any PC workstations, all Building Controllers, and other alarm printers within 15 seconds.
 - 2. Message and alarm buffering to prevent information from being lost.
 - 3. Error detection, correction, and re-transmission to guarantee data integrity.
 - 4. Synchronization of real-time clocks between Building Controllers, including automatic daylight savings time corrections.
 - 5. The primary network shall allow the Building Controllers to access any data from, or send control commands and alarm reports directly to, any other Building Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. Building Controllers shall send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device. The network shall also allow any Building controller to access, edit, modify, add, delete, back up, restore all system point database and all programs.
 - 6. The primary network controllers shall back-up and restore their own current database including programs, and points without the requirement for connection to a mass storage device.
 - 7. The primary network controllers shall provide system-wide wild card point search, command, and access direct from any building controller on the network.
 - 8. The primary network shall allow the Building Controllers to access on-demand display and reports regarding system-wide information including point names, point status, present value, command priority array, trend information, field panel configuration information.
 - 9. The primary network shall allow the Building Controllers to be configured system-wide by software based tools, and by direct access from any Building Controller on the network. Proprietary vendor specific software shall not be required for system configuration.
 - 10. The primary network shall allow the Building Controllers to assign password access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the PC workstation or portable terminal. (e.g. all base building and all tenant points shall be accessible to any base building operators, but only certain base building and tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.
 - 11. Devices containing custom programming may reside on the Primary Network.

L) BUILDING AUTOMATION SYSTEMS (BAS)

- f. Secondary Network – Advanced Application Controller (AAC) and Application Specific Controller (ASC) Communication:
 - i. Communication over the secondary network shall be BACnet MS/TP protocol.
 - ii. This level communication shall support a family of Advanced Application Controllers for pieces of equipment requiring full programmability and Application Specific Controllers for terminal equipment.
 - iii. The AACs and ASCs shall communicate bi-directionally with the Supervisory network through Supervisory Controllers for transmission of global data.
 - iv. A maximum of 96 terminal equipment controllers may be configured on individual secondary network trunk to insure adequate global data and alarm response times.
- g. Internet Based Communication:
 - i. Web Based Operator Interface
 - 1. The BAS shall provide a web based graphical interface that allows users to access the BAS data via the Internet, extranet, or Intranet. The interface shall use HTML based ASP pages to send and receive data from the BAS to a web browser.
 - 2. A web server computer will be supplied. The web server shall use Microsoft's IIS server with Windows 2003 Server, or Windows 2008 Server, or later, and support browser access via Microsoft Internet Explorer 5.0 (or higher), or Navigator Netscape 6.0 (or higher).
 - 3. All information exchanged over Internet shall be optionally encrypted and secure via SSL (provided by Owner).
 - 4. Access to the web interface may be password protected. Users' rights and privileges to points and graphics will be the same as those assigned at the BAS workstation. An option will exist to only allow users "read" access via the web browser, while maintaining "command" privileges via the BAS workstation.
 - 5. The web interface shall not require modification or creation of HTML or ASP pages using an HTML editor. All graphics available at the BAS graphical workstation shall be automatically generated to a web server.

- 6. The web based interface shall provide the following functionality to users, based on their access and privilege rights:
 - 1) Logon Screen - allows the user to enter their name, password and domain name for logging into the web server.
 - 2) Alarm Display - a display of current BAS alarms to which the user has access will be displayed. Users will be able to acknowledge and erase active alarms, and link to additional alarm information including alarm messages. Any alarm acknowledgments initiated through the web interface will be recorded to the BAS activity log.
 - 3) Graphic Display - Display of system graphics, including animated motion, available in BAS workstation will be available for viewing over the web browser. Software that requires the creation of dedicated "web" graphics in order to display the graphics via the browser interface will not be acceptable. A graphic selector list will allow users to select any graphics to which they have access. Graphics displays will automatically refresh with the latest change of values. Users will have the ability to command and override points from the graphic display as determined by their user account rights.
 - 4) Point Details - users will have access to point information including operational status, operational priority, physical address, and alarm limits, for point objects to which they have access.
 - 5) Point Commanding - users will be able to override and command points they have access to via the web browser interface. Any commands or overrides initiated via the web browser interface will be written to the BAS system central workstation activity log.
- 7. The web server licensing options will allow concurrent access by a minimum of five (5) browser connections.
- 8. Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the owner as required to support the web access feature.

- ii. Terminal Services Operator Interface
- iii. Client access to client-server workstation configurations over low-bandwidth network technologies shall be available optionally via Windows Terminal Services or Web browser interface. Remote client access via Windows Terminal Services shall provide multiple, independent sessions of the workstations software – Terminal Services clients shall have workstation software access, without the need to install the workstation software on the local hard drive]

L) BUILDING AUTOMATION SYSTEMS (BAS)

h. Remote Notification Paging System

- i. Workstations shall be configured to send out messages to numeric pagers, alphanumeric pagers, phones (via text to speech technology), SMS (Simple Messaging Service, text messaging) Devices, and email accounts based on a point's alarm condition.
- ii. There shall be no limit to the number of points that can be configured for remote notification of alarm conditions and no limit on the number of remote devices which can receive messages from the system.
- iii. On a per point basis, system shall be configurable to send messages to an individual or group and shall be configurable to send different messages to different remote devices based on alarm message priority level.
- iv. Remote devices may be scheduled as to when they receive messages from the system to account for operators' work schedules.
- v. System must be configurable to send messages to an escalation list so that if the first device does not respond, the message is sent on to the next device after a configurable time has elapsed.
- vi. Message detail shall be configurable on a per user basis.
- vii. During a "flood" of alarms, remote notification messages shall have the ability to optimize several alarms into an individual remote notification message.
- viii. Workstation shall have the ability to send manual messages allowing an operator to type in a message to be sent immediately.
- ix. Workstation shall have a feature to send a heartbeat message to periodically notify users that they have communication with the system.

L) BUILDING AUTOMATION SYSTEMS (BAS)

3. OPERATOR INTERFACE:

- a. Workstation hardware:
 - i. University of Chicago shall provide leased computers for all BAS systems.
- b. Server hardware:
 - i. The University of Chicago shall provide leased server capacity for use to the BAS shop and contractors.
- c. Operator Interface Software:
 - i. Basic Interface Description
 - 1. Operator interface software shall minimize operator training through the use of user-friendly and interactive graphical applications, 30-character English language point identification, on-line help, and industry standard Windows application software. Interface software shall simultaneously communicate with and share data between Ethernet-connected building level networks.
 - 2. Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device, with a “point and click” approach to menu selection and a “drag and drop” approach to inter-application navigation.
 - 3. The navigation shall be user friendly by utilizing “forward & back” capability between screens and embedded hyperlinks to open graphics, documents, drawings, etc.
 - 4. Selection of applications within the operator interface software shall be via a graphical toolbar menu – the application toolbar menu shall have the option to be located in a docked position on any of the four sides of the visible desktop space on the workstation display monitor, and the option to automatically hide itself from the visible monitor workspace when not being actively manipulated by the user.

- 5. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. BAS software shall run on a platform that mirrors the current University of Chicago campus IT&S operating systems standard. System database parameters shall be stored within an object- oriented database. Standard Windows applications shall run simultaneously with the BAS software. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BAS alarms and monitoring information
- 6. The software shall provide, as a minimum, the following functionality:
 - 1. Real-time graphical viewing and control of the BAS environment
 - 2. Reporting
 - 3. Scheduling and override of building operations
 - 4. Collection and analysis of historical data
 - 5. Point database editing, storage and downloading of controller databases.
 - 6. Utility for combining points into logical Point Groups. The Point Groups shall then be manipulated in Graphics, trend graphs and reports in order to streamline the navigation and usability of the system.
 - 7. Alarm reporting, routing, messaging, and acknowledgment
 - 8) “Collapsible tree,” dynamic system architecture diagram application:
 - a. Showing the real-time status and definition details of all workstations and devices on a management level network
 - b. Showing the real-time status and definition details of all Building Controllers at the Primary Network.
 - c. Showing the definition details of all application specific controllers

- 9. Definition and construction of dynamic color graphic displays.
- 10. Online, context-sensitive help, including an index, glossary of terms, and the capability to search help via keyword or phrase.
- 11. On-screen access to User Documentation, via online help or PDF-format electronic file.
- 12. Automatic database backup at the operator interface for database changes initiated at Building Controllers.
- 13. Display dynamic trend data graphical plot.
 - a. Must be able to run multiple plots simultaneously
 - b. Each plot must be capable of supporting 10 pts/plot minimum
 - c. Must be able to command points directly off dynamic trend plot application.
 - d. Must be able to plot both real-time and historical trend data
- 14. Program editing
- 15. Transfer trend data to 3rd party spreadsheet software
 - a. Scheduling reports
 - b. Operator Activity Log
 - c. Open communications via OPC Server
 - d. Open communications via BACnet Client & Server

L) BUILDING AUTOMATION SYSTEMS (BAS)

7. **Enhanced Functionality:**

1. Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via adjustable user-sized windows. Operator shall be able to drag and drop information between the following applications, reducing the number of steps to perform a desired function (e.g., Click on a point on the alarm screen and drag it to the dynamic trend graph application to initiate a dynamic trend on the desired point):
 - a. Dynamic color graphics application
 - b. Alarm management application
 - c. Scheduling application
 - d. Dynamic trend graph data plotter application
 - e. Dynamic system architecture diagram application editing applications
 - g. Reporting applications
2. Report and alarm printing shall be accomplished via Windows Print Manager, allowing use of network printers.

8. **Security:** Operator-specific password access protection shall be provided to allow the administrator/manager to limit users’ workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall “follow” the operator to any workstation logged onto the University of Chicago BAS VLAN network. The “BAS Shop” shall be able to grant discrete levels of access and privileges, per user, for each point, graphic, report, schedule, and BAS workstation application. And each BAS user account shall use a Windows Operating System user account as a foundation.

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

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

11. **Reports** shall be generated on demand or via pre-defined schedule, and directed to CRT displays, printers or file. As a minimum, the system shall allow the user to easily obtain the following types of reports:
1. A general listing of all or selected points in the network
 2. List of all points currently in alarm
 3. List of all points currently in override status
 4. List of all disabled points
 5. List of all points currently locked out
 6. List of user accounts and access levels
 7. List all weekly schedules and events
 8. List of holiday programming
 9. List of control limits and deadbands
 10. Custom reports from 3rd party software
 11. System diagnostic reports including, list of Building panels on line and communicating, status of all Building terminal unit device points
 12. List of programs
 13. List of point definitions
 14. List of logical point groups (Please see point grouping table for examples)
 15. List of alarm strategy definitions (Please see alarm nomenclature table)
 16. List of Building Control panels
 17. Point totalization report
 18. Point Trend data listings
 19. Initial Values report
 20. User activity report

L) BUILDING AUTOMATION SYSTEMS (BAS)

12. Scheduling and override

1. Provide a calendar type format for simplification of time and date scheduling and overrides of building operations. Schedule definitions reside in the PC workstation and in the Building Controller to ensure time equipment scheduling when PC is off-line, PC is not required to execute time scheduling. Provide override access through menu selection, graphical mouse action or function key. Provide the following capabilities as a minimum:
 - a. Weekly schedules
 - b. Zone schedules
 - c. Event schedules – an event consists of logical combinations of equipment and/or zones
 - d. Report schedules
 - e. Ability to schedule for a minimum of up to ten (10) years in advance.
2. Additionally, the scheduling application shall:
 - a. Provide filtering capabilities of schedules, based on name, time, frequency, and schedule type (event, zone, report)
 - b. Provide sorting capabilities of schedules, based on name, time and type of schedule (zone, event, report)
 - c. Provide searching capabilities of schedules based on name – with wildcarding options

13. Collection and Analysis of Historical Data

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

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

VOLUME III - DESIGN REQUIREMENTS

L) BUILDING AUTOMATION SYSTEMS (BAS)

14. Dynamic Color Graphic Displays

1. Capability to create color graphic floor plan displays and system schematics for each piece of mechanical equipment, including, but not limited to, air handling units, chilled water systems, hot water boiler systems, and room level terminal units.
2. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, point alarm association, or text-based commands. Graphics software shall permit the importing of Autocad or scanned pictures for use in the system.
3. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations within the system schematics or graphic floor plan displays, and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.
 - a. Provide the user the ability to display real-time point values by animated motion or custom picture control visual representation. Animation shall depict movement of mechanical equipment, or air or fluid flow. Picture Control shall depict various positions in relation to assigned point values or ranges. A library (set) of animation and picture control symbols shall be included within the operator interface software's graphics application. Animation shall reflect, ON or OFF conditions, and shall also be optionally configurable for up to five rates of animation speed.
 - b. Sizable analog bars shall be available for monitor and control of analog values; high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to "click and drag" the pointer to change the setpoint.
 - c. Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.
 - d. Equipment state or values can be changed by clicking on the associated point block or graphic symbol and selecting the new state (on/off) or setpoint.
 - e. State text for digital points can be user-defined up to eight characters.
4. Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.
5. Advanced linking within the Graphics application shall provide the ability to navigate to outside documents (e.g., .doc, .pdf, .xls, etc.), Internet web addresses, e-mail, external programs, and other workstation applications, directly from the Graphics application window with a mouse-click on a customizable link symbol.
6. The Windows environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
7. A template library of HVAC application and automation symbols shall be provided including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams and laboratory symbols. The BAS shop shall have the ability to add custom symbols to the template library. The clipart library shall include a minimum of 400 application symbols. In addition, a library consisting of a minimum of 700 graphic background templates shall be provided.
8. The Graphics application shall include a set of standard Terminal Equipment controller application-specific background graphic templates. Templates shall provide the automatic display of a selected Terminal Equipment controller's control values and parameters, without the need to create separate and individual graphic files for each controller.

L) BUILDING AUTOMATION SYSTEMS (BAS)

15. System Configuration & Definition

1. A “Collapsible tree,” dynamic system architecture diagram/ display application of the site-specific BAS architecture showing status of controllers, PC workstations and networks shall be provided. This application shall include the ability to add and configure workstations, Building Controllers, as well as 3rd-party integrated components. Symbols/ Icons representing the system architecture components shall be user- configurable and customizable, and a library of customized icons representing 3rd-party integration solutions shall be included. This application shall also include the functionality for real-time display, configuration and diagnostics connections to Building Controllers.
2. Network wide control strategies shall not be restricted to a single Building Controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.
3. Provide automatic backup and restore of all Building controller databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate Building Controller. Changes made at the user-interface automatically uploaded to the workstation, ensuring system continuity.
4. System configuration, programming, editing, graphics generation shall be performed on-line.
5. Point database configuration shall be available to the user within a dedicated point database editor application included in the operator interface software. The editor shall allow the user to create, view existing, modify, copy, and delete points from the database.
6. The point editor shall have the capability to assign “informational text” to points as necessary to provide critical information about the equipment.
7. The point editor shall also allow the user to configure the alarm management strategy for each point. The editor shall provide the option for editing the point database in an online or offline mode with the Building Controllers.

8. The operator interface software shall also provide the capability to perform bulk modification of point definition attributes to a single or multiple user-selected points. This function shall allow the user to choose the properties to copy from a selected point to another point or set of points. The selectable attributes shall include, but are not limited to, Alarm management definitions and Trend definitions.
9. Control program configuration shall be available to the user within a dedicated control program editor application included in the operator interface software. The editor shall allow for creation, modification and deletion of control programs. The editor shall include a programming assistance feature that interactively guides the user through parameters required to generate a control program. The editor shall also include the ability to automatically compile the program to ensure its compatibility with the Building Controllers. The editor shall provide the option for editing the control programs in an online or offline mode, and also the ability to selectively enable or disable the live program execution within the Building Controllers.

16. Alarm Management

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

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

L) BUILDING AUTOMATION SYSTEMS (BAS)

4. BUILDING CONTROLLER SOFTWARE

a. General:

- i. Furnish the following applications software to form a complete operating system for building and energy management as described in this specification.
- ii. The software programs specified in this Section shall be provided as an integral part of Building Controllers and shall not be dependent upon any higher level computer or another controller for execution.
- iii. The Building Controller Software shall be capable of BACnet communications. The BACnet Building Controller (B-BC) shall have demonstrated interoperability during at least one BTL Interoperability Workshop and shall substantially conform to BACnet Building Controller device profile as specified in ANSI/ASHRAE Standard 135- 2010.
- iv. Building Controllers shall have the ability to perform energy management routines including but not limited to time of day scheduling, calendar- based scheduling, holiday scheduling, temporary schedule overrides, start stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating / cooling interlock, supply temperature reset, priority load shedding, and power failure restart.
- v. The Building Controllers shall have the ability to perform the following pre tested control algorithms:
 1. Two position control
 2. Proportional control
 3. Proportional plus integral control
 4. Proportional, integral, plus derivative control
 5. Automatic tuning of control loops
 6. Model-Free Adaptive Control
- vi. Each Building Controller shall be provided with an interactive HELP function to assist operators using POTs and remote connected operators.

b. System Security

- i. User access shall be secured using individual security passwords and user names.
- ii. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager/ owner. Any access that exceeds the level originally specified by the owner needs approval by the BAS Manager.
- iii. User Log On / Log Off attempts shall be recorded.
- iv. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user- definable.
- v. Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the field panel.

c. User Defined Control Applications:

- i. Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
- ii. It shall be possible to use any system measured point data or status, any system calculated data, a result from any process, or any user-defined constant in any controller in the system.
- iii. Any process shall be able to issue commands to points in any and all other controllers in the system.
- iv. Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
- v. Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task-oriented information from the user manual.

d. Alarm Management:

- i. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each Network Controller shall perform distributed, independent alarm analysis, minimize network traffic and prevent alarms from being lost. At no time shall the Network Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.
- ii. Conditional alarming shall allow generation of alarms based upon user defined multiple criteria.
- iii. An Alarm “shelving” feature shall be provided to disable alarms during testing. (Pull the Plug, etc.).
- iv. Binary Alarms. Each binary object shall be set to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.
- v. Analog Alarms. Each analog object shall have both high and low alarm limits. Alarming must be able to be automatically and manually disabled.
- vi. All alarm or point change reports shall include the point’s user defined language description and the time and date of occurrence.
- vii. Alarm reports and messages shall be routed to user-defined list of operator workstations, or other devices based on time and other conditions. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display graphics.
- viii. In addition to the point’s descriptor and the time and date, the user shall be able to print, display or store an alarm message to more fully describe the alarm condition or direct operator response.
- ix. Each Network Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assignable to any number of points in the Controller.
- x. Operator-selected alarms shall be capable of initiating a call to a remote operator device.

L) BUILDING AUTOMATION SYSTEMS (BAS)**e. Scheduling:**

- i. Provide a comprehensive menu driven program to automatically start and stop designated multiple objects or events in the system according to a stored time.
- ii. Schedules shall reside in the building controller and shall not rely on external processing or network.
- iii. It shall be possible to define a group of objects as a custom event (i.e. meeting, athletic activity, etc.). Events can then be scheduled to operate all necessary equipment automatically.
- iv. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start and/or stop within that group.
- v. The operator shall be able to define the following information:
 1. Time, day
 2. Commands such as on, off, auto, etc.
 3. Time delays between successive commands.
 4. There shall be provisions for manual overriding of each schedule by an authorized operator.
- vi. All new fan systems shall have a default operational schedule of: Occupied 6:00 am and Unoccupied 9:00 pm.
- vii. It shall be possible to schedule calendar-based events up to one year in advance based on the following:
 1. Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop, and night economizer. When a group of objects are scheduled together as an Event, provide the capability to adjust the start and stop times for each member.
 2. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.

f. Temperature-compensated duty cycling:

- i. The DCCP (Duty Cycle Control Program) shall periodically stop and start loads according to various patterns.
- ii. The loads shall be cycled such that there is a net reduction in both the electrical demands and the energy consumed.

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

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

i. Enthalpy switchover (economizer). The Building Controller Software shall control the position of the air handler relief, return, and outside air dampers. If the outside air enthalpy falls below changeover set point the BCS will modulate the dampers to provide 100 percent outside air. The user will be able to quickly changeover to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.

j. Loop Control. A Model-Free Adaptive Control algorithm or alternatively a PID (proportional-integral-derivative) closed-loop control algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, set point, and weighting parameters shall be user-selectable.

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

l. Staggered Start:

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

m. Totalization:

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

L) BUILDING AUTOMATION SYSTEMS (BAS)

n. Data Collection:

- i. A variety of historical data collection utilities shall be provided to manually or automatically sample, store, and display system data for all points.
- ii. Building Controllers shall store point history data for selected analog and digital inputs and outputs:
 - 1. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each Building Controllers point group.
- iii. Trend data shall be stored at the Building Controllers and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either user-defined interval, manual command or when the trend buffers are full. All trend data shall be available for use in 3rd party personal computer applications.

- iv. Loop Tuning. Building Controllers shall also provide high resolution sampling capability for verification of DDC control loop performance. Documented evidence of tuned control loop performance shall be provided on a <monthly, seasonal, quarterly, annual> period.
 - 1. For Model-Free Adaptive Control loops, evidence of tuned control loop performance shall be provided via graphical plots or trended data logs. Graphical plots shall minimally include depictions of setpoint, process variable (output), and control variable (e.g., temperature). Other parameters that may influence loop control shall also be included in the plot (e.g., fan on/off, mixed-air temp).
 - 2. For PID control loops, operator-initiated automatic and manual loop tuning algorithms shall be provided for all operator-selected PID control loops. Evidence of tuned control loop performance shall be provided via graphical plots or trended data logs for all loops.
 - a. In automatic mode, the controller shall perform a step response test with a minimum one-second resolution, evaluate the trend data, calculate the new PID gains and input these values into the selected LOOP statement.
 - b. Loop tuning shall be capable of being initiated either locally at the Building Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

L) BUILDING AUTOMATION SYSTEMS (BAS)

5. BUILDING CONTROLLERS

- a. Building Controllers shall be at least 32 bit, multi-tasking, multi-user, real-time 100 MHz digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.
- b. Each Building Controller shall have sufficient memory, a minimum of 24 megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, and dial-up communications.
- c. Building Controllers shall have an integral real-time clock.
- d. Each Building Controller shall support firmware upgrades without the need to change hardware.
- e. Each Building Controller shall support:
 - i. Monitoring of industry standard analog and digital inputs, without the addition of equipment outside the Building Controller cabinet.
 - ii. Monitoring of industry standard analog and digital outputs, without the addition of equipment outside the Building Controller cabinet.
- f. Spare Point Capacity. Each Building Controller shall have a minimum of 10 percent spare point capacity.
 - i. The type of spares shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than one spare of each implemented I/O type.
 - ii. Provide all processors, power supplies, and communication controllers so that the implementation of adding a point to the spare point location only requires the addition of the appropriate:
 - 1. Expansion modules
 - 2. Sensor/actuator
 - 3. Field wiring/tubing.

- g. Serial Communication. Building Controllers shall provide at least one data communication port for operation of operator I/O devices such as industry standard printers, operator terminals, and portable laptop operator's terminals. Building Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected printers or terminals. A USB port shall alternatively be available to support local HMI tools connection.
- h. Self-Diagnostics. Each Building Controller shall continuously perform self diagnostics, communication diagnosis, and diagnosis of all panel components. The Building Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication for any system.
- i. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 100 hours.
- j. Environment.
 - i. Controller hardware shall be suitable for the anticipated ambient conditions for most mechanical spaces.
 - ii. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
 - iii. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

- k. Immunity to power and noise.
 - i. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
 - ii. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
 - iii. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
 - 1. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3 V
 - 2. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact
 - 3. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4- 4) at 500 V signal, 1 kV power
 - 4. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)
 - iv. Isolation shall be provided at all Building Controller's AC input terminals to suppress induced voltage transients consistent with:
 - 1. IEEE Standard 587 1980
 - 2. UL 864 Supply Line Transients
 - 3. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000- 4-11)

L) BUILDING AUTOMATION SYSTEMS (BAS)

6. Advanced Application Controllers (Aacs)

- a. Each Building Controller shall be able to communicate with Advanced Application Controllers (AACs) over the Secondary Network.
- b. AACs shall be at least 32 bit, multi-tasking, multi-user, real-time 100 MHz digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.
- c. Each AAC shall have sufficient memory, a minimum of 24 megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, and dial-up communications.
- d. AACs shall have an integral real-time clock.
- e. Each AAC shall support firmware upgrades without the need to change hardware.
- f. Each AAC shall support:
 - i. Monitoring of industry standard analog and digital inputs, without the addition of equipment outside the AAC cabinet.
 - ii. Monitoring of industry standard analog and digital outputs, without the addition of equipment outside the AAC cabinet.
- g. Spare Point Capacity. Each AAC shall have a minimum of 10 percent spare point capacity.
 - i. The type of spares shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than one spare of each implemented I/O type.
 - ii. Provide all processors, power supplies, and communication controllers so that the implementation of adding a point to the spare point location only requires the addition of the appropriate:
 - 1. Expansion modules
 - 2. Sensor/actuator
 - 3. Field wiring/tubing.

- h. Serial Communication. AACs shall provide at least one data communication port for operation of operator I/O devices such as industry standard printers, operator terminals, and portable laptop operator’s terminals. AACs shall allow temporary use of portable devices without interrupting the normal operation of permanently connected printers or terminals. A USB port shall alternatively be available to support local HMI tools connection.
 - i. Self-Diagnostics. Each AAC shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Building Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication for any system.
- j. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all AACs to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 100 hours.
- k. Environment.
 - i. Controller hardware shall be suitable for the anticipated ambient conditions for most mechanical spaces.
 - ii. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
 - iii. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

- l. Immunity to power and noise.
 - i. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
 - ii. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
 - iii. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
 - 1. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3 V
 - 2. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact
 - 3. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power
 - 4. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)
- iv. Isolation shall be provided at all AAC’s AC input terminals to suppress induced voltage transients consistent with:
 - 1. IEEE Standard 587 1980
 - 2. UL 864 Supply Line Transients
 - 3. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-1)

L) BUILDING AUTOMATION SYSTEMS (BAS)

7. Application Specific Controllers (Asc)

- a. General:
 - i. Each Building Controller shall be able to communicate with application specific controllers (ASCs) over the Secondary Network to control terminal equipment only.
 - ii. The use of Secondary Network controllers with custom program applications to control AHU's, water systems, etc. is not acceptable.
 - iii. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.
 - iv. Each ASC shall include all point inputs and outputs necessary to perform the specified control sequences. The ASC shall accept input and provide output signals that comply with industry standards. Controllers utilizing proprietary control signals shall not be acceptable. Outputs utilized either for two-state, modulating floating, or proportional control, allowing for additional system flexibility.
 - v. Space Temperature Sensors. Each controller performing space temperature control shall be provided with a matching room temperature sensor.
 1. Wired Sensor specifications. The sensor may be either RTD or thermistor type providing the following.
 - a. Accuracy: + .5 F
 - b. Operating Range: 35 to 115 F
 - c. Set Point Adjustment Range: 55 to 95 F
 - d. Calibration Adjustments: None required
 - e. Installation: Up to 100 ft. from controller
 - f. Auxiliary Communications Port: as required
 - g. Local LCD Temperature Display: as required
 - h. Set Point Adjustment Dial as required
 - i. Occupancy Override Switch as required
 2. Set Point Modes:
 - a. Independent Heating, Cooling
 - b. Night Setback-Heating
 - c. Night Setback-Cooling
 3. LCD Display. Interactive, two- line liquid crystal display shall allow the operator to query and modify operating parameters of the local room terminal unit from the room sensor. The display shall indicate the space temperature and associated ASC point when not being used to query or modify operating parameters.
 4. Set Point Adjustment. The set point adjustment feature shall allow for modification of the temperature set point by the building occupants and operators. Set point adjustment may be locked out, overridden, or limited as to time or temperature through software by an authorized operator at any central workstation, Building Controller, room sensor two-line display, or via the portable operator's terminal.
 5. Override Switch. An override switch shall initiate override of the night setback mode to normal (day) operation when activated by the occupant and enabled by building operators. The override shall be limited to two (2) hours (adjustable.) The override function may be locked out, overridden, or limited through software by an authorized operator at the operator interface, Building Controller, room sensor two-line display or via the portable operator's terminal.
 6. Space temperature sensors located in “public” spaces – corridors, entry ways, lobbies, libraries, classrooms, lecture halls, toilet rooms, bathrooms, etc. – are to be provided without display, with setpoint adjustment allowing adjustment within a pre-determined range set by the authorized facility operator, and with override switch which can be enabled or disabled on individual basis by the authorized facility operator. The University and authorized facility operator have the option of modifying individual sensor types and/or functionality. Coordinate with the University staff and authorized facility operator prior to the installation of the space temperature sensors.
 7. Space temperature sensors located in “private” spaces – private offices, open office areas, laboratory spaces, conference rooms, etc. – are to be provided with LCD display, with setpoint adjustment allowing adjustment within a pre-determined range set by the authorized facility operator, and with override switch which can be enabled or disabled on individual basis by the authorized facility operator. The University and authorized facility operator have the option of modifying individual sensor types and/or functionality. Coordinate with the University staff and authorized facility operator prior to the installation of the space temperature sensors.
 8. Provide discharge air temperature sensors on all VAV and constant volume terminal air units.
 - vi. Communication. Each controller shall perform its primary control function independent of other Secondary Network communication, or if Secondary Network communication is interrupted. Reversion to a fail- safe mode of operation during Secondary Network interruption is not acceptable.
 - vii. Control Algorithms. The controller shall receive its real-time data from the Building Controller time clock to insure Secondary Network continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via room sensor LCD or the portable operator's terminal as specified herein. Controllers that incorporate proportional and integral (PI) control algorithms only shall not be acceptable.
 - viii. Control Applications. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

L) BUILDING AUTOMATION SYSTEMS (BAS)

ix. Calibration. Each controller shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift over time.

1. Manual calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary
2. Calibration shall be accomplished by stroking the terminal unit damper actuator to a 0% position so that a 0 CFM air volume reading is sensed. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa.
3. Calibration shall be accomplished by zeroing out the pressure sensor and holding damper at last known position until calibration is complete. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa.

x. Memory.

1. Provide each ASC with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or minimum of 72-hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration.
2. Upon replacement, new ASCs shall recover control function and site specific defaults automatically and resume normal operation.

xi. Power Supply. The ASCs shall be powered from a 24 VAC source and shall function normally under an operating range of 18 to 28 VAC, allowing for power source fluctuations and voltage drops. Power supply for the ASC must be rated at a minimum of 125% of ASC power consumption and shall be of the fused or current limiting type. The controls contractor shall provide 24 VAC power to the terminal units by utilizing:

1. The existing line voltage power trunk and installing separate isolation transformers for each controller
2. Dedicated line voltage power source and isolation transformers at a central location and installing 24VAC power trunk to supply multiple ASCs in the area.

xii. Environment. The controllers shall function normally under ambient conditions of 32 to 122 F (0 to 50 C) and 10% to 95%RH (non- condensing). Provide each controller with a suitable cover or enclosure to protect the circuit board assembly.

xiii. Immunity to noise. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

xiv. Manufacturer Installed Controls.

1. The controls manufacturer shall furnish ASC and actuator for factory mounting to equipment manufacturer.
2. For VAV terminals where applicable, equipment manufacturer shall provide and install flow-cross sensor, 24 VAC transformer, controls enclosure, fan relay, SCR and factory install, wire and tube ASC controller and actuator.
3. Fan powered VAV terminals shall be equipped with a fan speed controller and relay to change summer and winter speed set point.

L) BUILDING AUTOMATION SYSTEMS (BAS)

8. INPUT / OUTPUT INTERFACE:

- a. Hardwired inputs and outputs may tie into the system through building or application specific controllers.
- b. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no damage to the controller.
- c. Binary inputs shall allow the monitoring of On/Off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense “dry contact” closure without external power (other than that provided by the controller) being applied.
- d. Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.
- e. Analog inputs shall allow the monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with—and field configurable to— commonly available sensing devices.
- f. Binary outputs shall provide for On/Off operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers shall have three-position (On/Off/Auto) override switches and status lights. Outputs shall be selectable for either normally open or normally closed operation.
- g. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC, 4 to 20 mA or 0-20 PSI signal as required to provide proper control of the output device. Analog outputs on building or custom application controllers shall have status lights and a two-position (AUTO/MANUAL) switch and manually adjustable potentiometer for manual override. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.

- h. Tri-State Outputs. Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices shall be limited to zone control and terminal unit control applications (VAV terminal units, duct-mounted heating coils, zone dampers, radiation, etc.). Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.
- i. System Object Capacity. The system size shall be expandable to at least twice the number of input/ output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

9. PANEL-MOUNT UNINTERRUPTIBLE POWER

SUPPLIES:

- a. Building Controller and critical systems field controllers should be on distributed building UPS power. If building UPS power is not available, provide separate UPS’s per controller/control panel as described below.
- b. Provide industrial style DIN-rail mounted uninterruptible power supply module in enclosure, to support BAS controllers and control panels where UPS input power is specified for those controllers and panels.

10. TOWER (OR RACK-MOUNTED) UNINTERRUPTIBLE POWER SUPPLIES:

- a. Provide uninterruptable power supplies (UPSs) to protect Building Controllers and “critical system” field controllers against power failure, power sag, power surge, under-voltage, over-voltage, line noise, frequency variation, switching transients, and harmonic distortion.
- b. UPSs shall be tower type with LCD display/interface, rated for 700-3000 VA, be >95% efficient, and include battery backup.
- c. Features shall include hot-swappable batteries and built-in external maintenance bypass, providing line power to the protected equipment during periods when the UPS is out of service for maintenance, repair, or replacement.
- d. UPS shall be equipped with communication card enabling connectivity via Ethernet IP protocol to be monitored directly by the ITS Department. [Option: Modbus RTU protocol to enable communication with and monitoring by the BAS system]
- e. Basis of design product: Eaton model 9130 with communication card option.

L) BUILDING AUTOMATION SYSTEMS (BAS)

11. Power Supplies And Line Filtering

- a. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.
- b. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand a 150% current overload for at least three seconds without trip-out or failure.
 - i. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
 - ii. Line voltage units shall be UL recognized and CSA approved.
- c. Power line filtering and surge protection.
 - i. Provide transient voltage and surge suppression for all workstations, network controllers and other critical panels either internally or as an external component. Surge protection shall have the following at a minimum:
 - 1. Dielectric strength of 1000 volts minimum
 - 2. Response time of 10 nanoseconds or less
 - 3. Transverse mode noise attenuation of 65 dB or greater
 - 4. Common mode noise attenuation of 150 dB or better at 40 Hz to 100 Hz.
 - 5. Hot swappable batteries
 - 6. Automatic voltage regulation
 - 7. Automatic bypass
 - 8. Energy efficient design
 - 9. Remote on/off
 - 10. Web/SNMP enabled

12. Axiliary Control Devices

- a. General
 - i. Specified in this section are the following hard wired input/output devices connected to the Building Controller or ASC.
 - 1. All Automatic Dampers, Valves, Actuators
 - 2. Airflow Measuring Stations (serial data communication also)
 - 3. Binary Temperature Devices
 - 4. Temperature Sensors
 - 5. Dew Point/Humidity Sensors
 - 6. Pressure Sensors
 - 7. Refrigerant Monitor System
 - 8. Analog Water Level Sensors
 - 9. Water Leak Detection Systems
 - 10. Audio/Visual Alarm Units
 - 11. Fuel Oil Meters
 - 12. In-Line Flanged Electromagnetic Flow Meters for Hydronic Measurements
 - 13. Energy BTU Meters
 - 14. Vortex Shedding Flow Meters
 - 15. In-Line Makeup Water, Blowdown, and Condensate Meters
 - 16. Indoor Air Quality (CO2) Sensors
 - 17. Continuous Indoor Air Quality Monitors (PM, CO2, TVOC, RH, Temp, etc.)
 - 18. Relays
 - 19. Override Timers
 - 20. Current Transformers
 - 21. Voltage Transmitters
 - 22. Voltage Transformers
 - 23. Power Monitors
 - 24. Current Switches
 - 25. Pressure Electric Switches
 - 26. Electro-pneumatic Transducers
 - 27. Local Control panels
 - 28. Room Pressure Monitor
 - 29. User Interface Touch Screen Display
 - 30. Differential Pressure Monitor
 - 31. Local User Display

- ii. Specified in this section are the following devices connected to the BAS using serial communication.

- 1. Water BTU Meters
- 2. Mass Flow Meters
- 3. Variable Frequency Drives (VFD)
- 4. Air Flow Measuring Stations
- 5. Boilers/Boiler Controls Panels
- 6. Chillers/Chiller Control Panels
- 7. Power Monitors
- 8. Room Pressure Monitors
- 9. Utility Meters
- 10. Lighting Control Panels

b. All Automatic Dampers, Valves, Actuators

- i. Dampers:
 - 1. All automatic dampers furnished by this Contractor for modulating control shall be of the proportioning type with opposed or parallel blades depending on the application or as shown on the drawings; dampers for two position action may be of the parallel blade type.
 - 2. Automatic dampers shall be manufactured by TAMCO or Ruskin and shall meet the requirements detailed below.
 - 3. All dampers for outdoor air service to be equal to TAMCO Series 9000 aluminum and have the following features:
 - a. Frames shall be 4” deep x 1” and no less than .080” in thickness, mill finish extruded aluminum 6063-T5 with mounting flanges on both sides of the frame. Frame to be assembled using plated steel mounting fasteners.
 - b. Entire frame shall be thermally broken by means of two polyurethane resin pockets complete with thermal cuts.
 - c. Blades shall be extruded aluminum 6063-T5, mill finish air foil profiles, internally insulated with expanded polyurethane foam and shall be thermally broken.
 - d. Blade and frame seals shall be of extruded silicone and shall be secured in an integral slot within the aluminum extrusions. Blade and frame seals are to be mechanically fastened to eliminate shrinkage and movement over the life of the damper. Adhesive or clip on type blade seals shall not be approved.

L) BUILDING AUTOMATION SYSTEMS (BAS)

- e. Maintenance free bearings are to be composed of an inner bearing fixed to a 7/16” aluminum hexagon blade pivot pin, rotating within a polycarbonate outer bearing inserted into the frame. There shall be no metal-to-metal or metal-to-plastic contact.
- f. Adjustable 7/16” hexagonal drive rod, U-bolt fastener and hexagonal retaining nuts shall be corrosion resistant, zinc plated steel to provide positive connection to blades and linkage.
- g. Linkage hardware shall be installed in the frame side. All linkage crank arm and rod hardware parts shall be constructed of mill finished aluminum, complete with corrosion resistant, zinc plated trunnions and cup point trunnion screws for a slip- proof grip.
- h. Dampers are to be designed for operation in temperatures ranging between -40 deg. F (-40 deg. C) and 212 deg. F (100 deg. C).
- i. Dampers shall be rated Leakage Class 1A at 1 in. w.g. (0.25 kPa) static pressure differential. Standard air leakage data shall be certified under the AMCA Certified Ratings Program.
- j. Dampers shall be made to size required without blanking off free area.
- k. Dampers shall be available with either opposed blade action or parallel blade action.
- l. Dampers shall be available as “flanged to duct” mounting type.
- m. Installation of dampers must be in accordance with manufacturer’s installation guidelines provided with each damper shipment.
- n. Intermediate or tubular steel structural support is required to resist applied pressure loads for dampers that consist of two or more sections in both height and width. (See manufacturer’s installation guidelines).

- 4. Dampers for all other applications to be equal to TAMCO Series 1500 Ultra Low Leakage Air Foil Aluminum and have the following features:
 - a. Frames shall be 4” deep x 1” and no less than .080” in thickness, mill finish extruded aluminum 6063-T5 with mounting flanges on both sides of the frame. Frame to be assembled using plated steel mounting fasteners.
 - b. Entire frame shall be thermally broken by means of two polyurethane resin pockets complete with thermal cuts.
 - c. Blades shall be extruded aluminum 6063-T5, mill finish air foil profiles, internally insulated with expanded polyurethane foam and shall be thermally broken.
 - d. Blade and frame seals shall be of extruded silicone and shall be secured in an integral slot within the aluminum extrusions. Blade and frame seals are to be mechanically fastened to eliminate shrinkage and movement over the life of the damper. Adhesive or clip on type blade seals shall not be approved.
 - e. Maintenance free bearings are to be composed of an inner bearing fixed to a 7/16” aluminum hexagon blade pivot pin, rotating within a polycarbonate outer bearing inserted into the frame. There shall be no metal-to-metal or metal-to-plastic contact.
 - f. Adjustable 7/16” hexagonal drive rod, U-bolt fastener and hexagonal retaining nuts shall be corrosion resistant, zinc plated steel to provide positive connection to blades and linkage.
 - g. Linkage hardware shall be installed in the frame side. All linkage crank arm and rod hardware parts shall be constructed of mill finished aluminum, complete with corrosion resistant, zinc plated trunnions and cup point trunnion screws for a slip- proof grip.
 - h. Dampers are to be designed for operation in temperatures ranging between -40 deg. F (-40 deg. C) and 212 deg. F (100 deg. C).

- i. Dampers shall be rated Leakage Class 1A at 1 in. w.g. (0.25 kPa) static pressure differential. Standard air leakage data shall be certified under the AMCA Certified Ratings Program.
 - j. Dampers shall be made to size required without blanking off free area.
 - k. Dampers shall be available with either opposed blade action or parallel blade action.
 - l. Dampers shall be available as “flanged to duct” mounting type.
 - m. Installation of dampers must be in accordance with manufacturer’s installation guidelines provided with each damper shipment.
 - n. Intermediate or tubular steel structural support is required to resist applied pressure loads for dampers that consist of two or more sections in both height and width. (See manufacturer’s installation guidelines).
- 5. Automatic dampers (modulating) shall be designed for face velocity that varies from 1,200 fpm to 2,000 fpm in most cases as approved by the design engineer. Dampers to be selected by the supplier with blade shaft lengths that prevent torsion that will create a leakage of more than 2 percent of the rated leakage capacity. Beyond that point, the dampers shall be broken into multiple sections. Field supplied mullions are required on large dampers exceeding 200 square feet.
 - 6. Individual damper section actuators are preferred unless access to actuators is difficult and then jack shafting is acceptable. ECC to note that drive shafts between dampers of different air paths (i.e., outdoor air and return air or return air and exhaust air) is not acceptable. Jack shafting between sections is permitted when such shafting is designed to accommodate and eliminate the effects of torsion.
 - 7. ECC to note that free access to all actuators is the responsibility of the ECC.

L) BUILDING AUTOMATION SYSTEMS (BAS)

8. Each damper shall be equipped with an individual damper operator of the size and style required for the service intended.

9. Actuators to be designed for modulating control with spring return to the fail “safe” position. Actuators to be low voltage with 100% surplus torque (submittals to incorporate calculations to prove 100 percent closure under 4.0” wg status pressure differential for modulating service and 2.0” wg for two position application).

10. Terminal box/AFCV damper actuators to be low voltage, non- spring return, incremental control with 200 percent torque. All control actuators to utilize auto zero program to insure total accuracy of damper actuator. The feature to be activated during periods of low or no occupancy.

11. Pneumatic damper actuators to be piston type of the size and style to meet application. All modulating dampers to be equipped with pilot positioners to make the full power of the actuator available as well as to allow the operating range and starting point of the actuator to be field adjusted.

ii. Control Valves:

1. Manufacturer: Manufactured, brand labeled or distributed by Belimo, Johnson Controls, Inc., or Siemens

2. Control valve actuators:

a. Size for valve close off at 150 percent of total system (head) pressure for two-way valves and 100 percent of pressure differential across the valve or 100 percent of total system (pump) head differential pressure for three-way valves.

b. Coupling: Directly couple and mount to valve stem and shaft ISO style direct-coupled mounting pad.

c. Shall meet all the requirements of 2.1.E Electronic Actuators.

3. Control valves:

a. Factory fabricated of type, body material and pressure class based on maximum pressure and temperature rating of piping system unless otherwise indicated.

b. Sizing:

i. Two-position: Line size or size using a pressure differential of 1 psi.

ii. Two-way modulating: 5 psid or twice the load pressure drop, whichever is more.

iii. Three-way modulating: Twice the load pressure drop, but not more than 5 psid.

c. Sizing (steam):

i. Two-position: Line size or sized using 10% of inlet gauge pressure.

ii. Modulating: 15 psig or less inlet steam pressure, the pressure drop shall be 80% of inlet gauge pressure. Higher than 15 psig inlet steam pressure, the pressure drop shall be 42% of the inlet absolute pressure.

d. Close-off pressure rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system head pressure for two-way valves and 150 percent of the design pressure differential across the three-way valves. **[Combination of actuator and trim shall provide minimum close-off pressure rating of 100 psid.]**

e. The control valve assembly shall be provided and delivered from a single manufacturer as a complete assembly.

4. The manufacturer shall warrant all components for a period of 5 years from the date of production with the first two years unconditioned (except as noted).

5. Pressure independent control valves:

a. NPS 2 and smaller: Forged brass body rated at no less than 400 psi, chrome plated brass ball and stem, female NPT union ends, dual EPDM lubricated O-rings and a brass Tefzel characterizing disc.

b. NPS 2-1/2 through 6: GG25 cast iron body according to ANSI Class 125, Standard Class B, stainless steel ball and blowout proof stem, flange to match ANSI 125 with a dual EPDM O-ring packing design, PTFE seats and a stainless steel flow characterizing disc.

c. Accuracy: The control valves shall accurately control the flow from 0 to 100% full rated flow with an operating pressure differential range of 5 to 50 psi differential across the valve with a valve body accuracy of ±5% variance due to different pressure fluctuation or ±10% total assembly error incorporating differential pressure fluctuation, manufacturing tolerances and valve hysteresis.

d. Flow characteristics: Equal percentage characteristics.

e. All actuators shall be capable of being electronically programmed in the field by use of external computer software or a dedicated handheld tool for the adjustment of flow. Programming using actuator mounted switches or multi-turn actuators are not acceptable.
- The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.
- THE UNIVERSITY OF CHICAGO FACILITIES SERVICES
- FS² Volume III - Design Requirements | Page 174

L) BUILDING AUTOMATION SYSTEMS (BAS)

6. Characterized control valves:

a. NPS 2 and smaller: Nickel plated forged brass body rated at no less than 400 psi, stainless steel ball and blowout proof stem may be female NPT, sweat connection or pressure connect end fittings with a dual EPDM O-ring packing design, fiberglass reinforced Teflon seat or graphite reinforced PTFE seats and a flow characterizing disc.

b. NPS 2-1/2 through 3: GG25 cast iron body according to ANSI Class 125, Standard Class B, stainless steel ball and blowout proof stem, flange to match ANSI 125 with a dual EPDM O-ring package design, PTFE seats and a stainless steel flow characterizing disc.

c. For steam applications, NPS 1 and smaller: Nickel plated forged brass body rated at no less than 600 psi, stainless steel ball and blowout proof stem, female NPT end fittings with a dual EPDM O-ring packing design, fiberglass reinforced PTFE Teflon seats and a PTFE Teflon flow characterizing disc. Flow characteristics: Equal percentage characteristics.

d. Globe valves shall have the following characteristics:

i. NSP 2 and smaller: ANSI Class 250 bronze body, stainless steel stem, brass plug, bronze seat and a TFE packing.

ii. NPS 2-1/2 and larger: ANSI Class [125][250] cast iron body, stainless steel stem, bronze plug, bronze seat and a TFE V-ring packing.

iii. Flow characteristics: Two-way valves shall have equal percentage characteristics. Three-way valves shall have linear characteristics.

iv. Two and three way globe valves shall be used only if characterized control valves do not fit the sizing criteria or application.
- e. For steam applications, globe valves shall have the following characteristics:

i. NPS 2 and smaller: ANSI Class 250 bronze body, stainless steel seat, stem and plug and a TFE packing.

ii. NPS 2-1/2 and larger: ANSI Class [125][250] cast iron body, stainless steel seat, stem and plug and a TFE V- ring packing.

iii. Flow characteristics: Linear or equal percentage characteristics.
7. Butterfly valves – resilient seat:

a. NPS 2 and 12: Valve body shall be full lugged cast iron 200 psig body with a 304 stainless steel disc, EPDM seat, extended neck and shall meet ANSI Class 125/150 flange standards. Disc-to-stem connection shall utilize an internal spine. The shaft shall be supported at four locations by RPTFE bushings.

b. NPS 14 and larger: Valve body shall be full lugged cast iron 150 psig body with a 304 stainless steel disc, EPDM seat, extended neck and shall meet ANSI Class 125/150 flange standards. Disc-to-stem connection shall utilize a dual pin method to prevent the disc from settling onto the linear. The shaft shall be supported at four locations by RPTFE bushings.

d. Sizing:

i. Two position: Line size or size using a pressure differential of 1 psi.

ii. Modulating: [3 psig][5 psig] or twice the load pressure drop, whichever is more. Size for the design flow with the disc in a 60 degree open position and a design velocity not-to-exceed 12 feet per second.

e. Close off pressure rating:

i. NPS 2-12” 200 psi bubble tight shutoff.

ii. NPS 14 and larger: 150 psi bubble tight shutoff.
8. Butterfly valves – high performance:

a. Valve body shall be full lugged carbon steel ANSI Class [150][300] body with a 316 stainless steel disc without a nylon coating, RTFE seat and be ANSI Class 150/300 flange standards. Blowout proof shaft shall be 17-4 ph stainless steel and shall be supported at four locations by glass backed TFE bushings. Valve packing shall be Chevron TFE and shall include fully adjustable packing flange and separable packing gland. Valve body shall have long stem design to allow for 2” insulation (minimum). Valve face-to-face dimensions shall comply with API 609 and MSS-SP-68. Valve assembly shall be completely assembled and tested, ready for installation.

b. Sizing:

i. Two position: Line size or size using a pressure differential of 1 psi.

ii. Modulating: [3 psig][5 psig] or twice the load pressure drop, whichever is more. Size for the design flow with the disc in a 60 degree open position and a design velocity not-to-exceed 12 feet per second.

c. Flow characteristics: Modified equal percentage, unidirectional.

d. Close off pressure rating: [150][285] psi bubble tight shutoff.

e. Media temperature range: ANSI Class [150][300] limitations.

f. Max differential pressure: 285 psi at 100 deg. F for ANSI 150 (725 psi at 100 deg. F. for ANSI 300).
9. Zone valves (on/off two position applications):

a. NPS 1 and smaller: Forged brass body rated at no less than 300 psi, stainless steel stems, female, NPT union or sweat with a stainless steel stem or EPDM seals.

b. The manufacturer shall warrant all components for a period of 2 years from the date of production.

L) BUILDING AUTOMATION SYSTEMS (BAS)

iii. Electronic Actuators:

1. Manufactured, brand labeled or distributed by Belimo, Johnson Controls, Inc., or Siemens.
2. Size for torque required for damper seal at load conditions.
3. Coupling: V-bolt dual nut clamp with a V-shaped, toothed cradle.
4. Mounting: Actuators shall be direct shaft mount type. Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.
5. Overload protected electronically throughout rotation. mechanism. **[Electronic fail safe shall incorporate a visual indication of the fail safe status on the face of the actuator. The power fail position shall be field adjustable between 0 to 100% in 10 deg. F increments. The electronic fail safe shall have a 2 second (adjustable) operational delay.]**
7. Power requirements (spring return): 24 VAC, maximum 15 VA at 24 VAC or 8 W at 24 VDC.
8. Proportional actuators shall be fully programmable through an EEPROM without the use of actuator mounted switches.
9. Temperature rating: -22 deg. F to +122 deg. F.
10. Housing: Minimum requirement NEMA Type 2/IP54 mounted in any orientation. NEMA 4/4X (IP67) required for outdoor applications.
- 11 Agency listings: ISO 9001 or UL.
12. The manufacturer shall warrant all components for a period of 5 years from the date of production with the first two years unconditional.
13. All damper actuators used on equipment introducing outdoor air shall be furnished with mechanical spring return mechanism as indicated in “fail safe operation” above.
14. All actuators shall have external adjustable stops to limit the travel in either direction and a gear release to allow manual positioning.

15. Actuators shall be provided with position feedback signal (2-10 VDC or 4-20 mA) where indicated on HPE drawings. Feedback signal shall be independent of the input signal and shall provide true position indication.

16. Actuators on chilled water supply and return isolation valves (that isolate building from campus chilled water supply) shall be equipped with end switches positively indicating, through the building BAS system, the valves have been closed for the season.

iv. Industrial Actuators (Only to be used with Butterfly Valves – Resilient Seat and Butterfly Valves – High Performance):

1. Manufacturer, brand labeled or distributed by Belimo, Johnson Controls, Inc., or Siemens
2. The combination of valve and actuator shall meet the close-off requirements as specified in the “Butterfly Valves” portion of this Specification.
3. Coupling: ISO 5211 mounting standards.
4. Overload protection: A self-resetting thermal switch embedded in the motor.
5. Manual override: Actuator shall be equipped with a hand wheel or shaft for manual override to permit operation of the actuator in the event of an electrical power failure.
6. Power requirements: [24 VAC][120 VAC] 1 PH.
7. Auxiliary switches: 2 SPDT rated 3A at 250 VAC.
8. Temperature rating: -22 deg. F to +150 deg. F.
9. Housing: Minimum requirement NEMA Type 4X/IP67 with an industrial quality coating. Actuator shall have an internal heater to prevent condensation within the housing. A visual indication beacon shall indicate position status of the device.
10. Agency listing: ISO, UL.
11. The manufacturer shall warrant for 2 years from the date of production.

c. Air Flow Measuring Stations

- i. Duct-mounted stations shall be installed by the Sheet Metal Contractor while fan inlet station installation responsibility shall be by this Contractor.
- ii. Sizing and physical location of stations shall be the responsibility of this Contractor. ECC to insure that sufficient distance is available both upstream and downstream such that turbulence is not a factor in the velocity pressure measurement. Sizing shall insure that the minimum velocity across the station affords accuracy of measurement and the design engineer shall be notified within 30 days of contract award if any modifications are required to the field ductwork.
- iii. ECC to insure that a proper access door upstream of the station is provided in the ductwork such that the inlet face of the unit may be cleaned as necessary.
- iv. Thermal Dispersion Air Flow Measurement:
 1. Air volume measurement system to consist of multiple sensors designed to average velocity using thermal dispersion principles. Sensor probes shall be factory calibrated to NIST_traceable standards. Sensor probes to be Type 6063 gold anodized aluminum or Type 316 SS. Depending on the application, probes may be duct- mounted or fan-inlet type. System to be designed to be totally independent of temperature, density, and humidity. Tek-Air or Ebtron
 2. The quantity of sensing tubes shall conform to manufacturer’s requirements for spacing based on the specified accuracy and the actual inlet and outlet conditions.
 3. Unit to be accurate to 2.0% of reading between 50 fpm and 5,000 fpm.
 4. Output Interface:
 - a. Airflow and temperature outputs to be 4-20 mA.
 - b. 10 Base-T Ethernet Output for full duplex communication - field selectable for BACnet Ethernet, BACnet IP, Modbus TCP or TCP/IP
 - c. Programmable alarm can be configured for user defined High or Low Limit or transmitter/probe fault conditions

L) BUILDING AUTOMATION SYSTEMS (BAS)

d. Binary Temperature Devices

i. Line-voltage space thermostat:

1. Line-voltage thermostats shall be bimetal-actuated, snap acting SPDT contact, enclosed, UL listed for electrical rating. The thermostat cover shall provide exposed set point adjustment knob. The thermostat shall operate within the 55°F to 85°F setpoint range, with 2°F maximum differential.

ii. Low-temperature safety thermostat:

1. Low-temperature safety thermostats shall be manually reset, line voltage with maximum 23'-0" flexible sensing elements responsible to lowest temperature along entire length. Furnish minimum two (2) wired in series on the discharge side of the first hydronic coils (i.e., a 4-section coil requires eight low limit thermostats wired in series). Contractor to note that the operating head of such instruments shall be shielded from conditions whereby it could be activated by low temperature. Clarify location of low limits with the Engineer during submittal review if HPE Sheets illustrate a location other than the discharge side of the first hydronic coil.
2. All flexible averaging sensors shall be attached by wire ties to a suspended wire or insulated cable to prevent sensor contact with metal or other unit components.
3. Install flexible sensors across all coils at a maximum of 6" from the bottom of the bottom coil and a minimum of 7" diameter to turn the sensor. Install the detector with a maximum free distance of 12" between each pass.
4. Staggered coils shall utilize multiple sensors. Each sensor shall cover one section of the staggered coil. Sensing elements shall be a minimum of 17' long.
5. All flexible sensors shall be protected at point of penetration of unit via a section of poly tubing to prevent contact of the sensor and the unit.
6. Mount detector within 6" of the face of the coil unless noted otherwise. For staggered coil banks, this requirement applies for each half of the bank

7. ECC to note that when any low-temperature safety controls are above an elevation 7'-0" above floor level or otherwise inaccessible, they shall employ automatic reset and shall be wired to an auxiliary control panel of a 5'-0" elevation. The control panel with piano hinged door shall utilize a latching reset relay for each individual low limit control which insures that the fan is de-energized even as the low limit resets automatically. The panel face shall utilize a red alarm pilot light that remains lit until the 10 second time delay reset relay momentary contact switch is activated. An LED inside the panel shall indicate which of low limits has signaled the alarm.

iii. Aquastat:

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

L) BUILDING AUTOMATION SYSTEMS (BAS)

e. Temperature Sensors.

- i. Provide the following instrumentation as required by the monitoring, control and optimization functions. All temperature sensor shall use platinum or nickel RTD elements only, silicon elements are not acceptable. All control signals shall be via a 4-20 mA loop. For critical system applications, only temperature transmitters will be accepted. RTDs and transmitters are acceptable for non-critical applications.
- ii. Room Temperature:
 - 1. Temperature monitoring range+40/+90 F (+40/120 F for high temp alarms)
 - 2. Output signal4-20 mA, 0-10VDC, 1k ohm
 - 3. Installation adjustments none required
 - 4. Calibration adjustments zero & span
 - 5. Factory calibration point 70 deg F
 - 6. Accuracy at calibration point +0.5 F
- iii. Liquid Immersion Temperature
 - 1. Temperature monitoring range+20/+120 F or +70/+220 F
 - 2. Output signal4-20 mA, 0-10VDC, (only)
 - 3. Installation adjustment none required
 - 4. Calibration adjustments zero & span
 - 5. Factory calibration point 70 deg F
 - 6. Accuracy at calibration point +0.5 F
- iv. Duct (Single Point) Temperature
 - 1. Temperature monitoring range+20/+120 F
 - 2. Output signal4-20 mA, 0-10VDC, 1k ohm
 - 3. Installation adjustments none required
 - 4. Calibration adjustments zero & span
 - 5. Factory calibration point 70 deg F
 - 6. Accuracy at calibration point +0.5 F
- v. Duct (Averaging) Temperature
 - 1. Temperature monitoring range+20/+120 F
 - 2. Output signal4 - 20 mA, 0-10VDC, 1k ohm
 - 3. Installation adjustments none required
 - 4. Calibration adjustments zero & span
 - 5. Factory calibration point 70 deg F
 - 6. Accuracy at calibration point +0.5 F

vi. Outside Air Temperature

- 1. Temperature monitoring range-50/+122
- 2. Output signal4-20 mA, 0-10VDC, 1k ohm
- 3. Installation adjustments none required
- 4. Calibration adjustments zero & span
- 5. Factory calibration point 70 deg F
- 6. Accuracy at calibration point +0.5 Fstations. Outdoor air temperature and humidity values should be communicated from the central weather station (primary) nearest the building affected by these specifications. Should the primary weather station fail or lose communication, the outdoor air temperature and humidity values shall be communicated from the backup (secondary) central weather station. Should the secondary weather station fail, lose communication, or if the BAS network fail, the local building BAS network shall use the outdoor air sensor installed for that building (if applicable). If a local sensor is not connected or available, the building BAS system shall utilize the last communicated outdoor air temperature and humidity values until the communication with the primary weather station is restored.

f. Dew Point/Humidity Sensors

- i. Outside Air Dew Point Temperature
 - 1. Dew point monitoring range -40/+115 F DP, 12% to 99% RH
 - 2. Output signal4-20 mA
 - 3. Calibration adjustments zero & span
 - 4. Factory calibration point 70 F
 - 5. Accuracy at calibration point +2.0 Fdp
 - 6. The University employs two Central Weather stations. Outdoor air temperature and humidity values should be communicated from the central weather station (primary) nearest the building affected by these specifications. Should the primary weather station fail or lose communication, the outdoor air temperature and humidity values shall be communicated from the backup (secondary) central weather station. Should the secondary weather station fail, lose communication, or if the BAS network fail, the local building BAS network shall use the outdoor air sensor installed for that building (if applicable). If a local sensor is not connected or available, the building BAS system shall utilize the last communicated outdoor air temperature and humidity values until the communication with the primary weather station is restored.
- ii. Room/duct Relative Humidity
 - 1. Sensor Humidity range 0 to 100%
 - 2. Operating temperature 15 F to +170 F
 - 3. Accuracy +2% RH
 - 4. Sensing element Capacitive sensor
 - 5. Output signal4-20 mA DC
 - 6. Installation adjustments zero & span
 - 7. Operating temperature 15 F to +170 F
 - 8. Voltage requirement 12-36 VDC

L) BUILDING AUTOMATION SYSTEMS (BAS)

g. Differential Pressure Sensors

i. General Air and Water Pressure Sensor Requirements:

- 1. Pressure sensors shall be constructed to withstand 100% pressure over-range without damage and to hold calibrated accuracy when subject to a momentary 40% over-range input.
- 2. Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.
- 3. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing contractor and Owner permanent easy-to-use connection.
- 4. Provide a minimum of a NEMA 1 housing for the transmitter. Locate transmitters in accessible local control panels wherever possible.
- 5. Provide a two year warranty for each transmitter. Replace all transmitters found to be defective at no cost to the Owner during the warranty period.

ii. Water Differential Pressure Applications

- 1. The differential pressure transmitter shall be of industrial quality and transmit a linear 4 to 20 mA output in responseto variation of differential pressure or air pressure sensing points.
- 2. The differential pressure transmitter shall have non-interactive zero and span adjustments adjustable from the outside cover and meet the following performance specifications:
 - a. Maximum differential pressure range 1 to 100 psi. Select range appropriate for system application.
 - b. Reference Accuracy: $\pm 0.5\%$ of full span (includes non-linearity, hysteresis, and repeatability).
 - c. Transmitter shall be temperature compensated.
- 3. Mount stand-alone pressure transmitters in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with hi and low connections piped and valved. Air bleed units, bypass valves and compression fittings shall be provided.

4. Acceptable Manufacturers: Rosemount Model 3051.

iii. Pump Differential Pressure Applications

- 1. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure sensing points.
- 2. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage. Pressure transmitters shall be constructed to withstand 500% pressure over-range without bursting.
- 3. The differential pressure transmitter shall have dip-switch selectable operating range adjustments, adjustable from inside the cover. The differential pressure transmitter shall have push- button zero adjustment, resettable from inside the cover.
- 4. The differential pressure transmitter shall meet the following performance specifications:
 - a. Maximum differential pressure range 2 to 250 psi. Select range appropriate for system application.
 - b. Reference Accuracy: $\pm 1.0\%$ of full span (includes non-linearity, hysteresis, and repeatability).
 - c. Transmitter shall be temperature compensated.
- 5. The differential pressure transmitter shall be remotely mounted at the process. The differential pressure transmitter and electronics shall be enclosed in a NEMA 4 enclosure.
- 6. The differential pressure transmitter shall have a LCD display for local indication of; high port pressure, low port pressure, and differential pressure.
- 7. The transmitter shall be installed with high and low connections piped and valved. Air bleed units, bypass valves and compression fittings shall be provided.
- 8. The differential pressure transmitter shall have a 5 year warranty.
- 9. Acceptable Manufacturers: Veris Industries PW2 Series, or approved equivalent.

iv. Building/Space Differential Air Pressure Applications (Critical Applications)

- 1. The differential pressure transmitter shall use variable capacitance technology with digital compensation and transmit a linear 0-10 VDC output in response to variation of differential pressure. Pressure transmitter shall be NIST traceable.
- 2. Accuracy: $\pm 0.5\%$ of span, including non-linearity, hysteresis, non- repeatability, zero offset and span setting errors.
- 3. Long-term stability: $<0.25\%$ per year
- 4. Mounting: DIN rail or standard panel mounting options
- 5. Provide shielded static pressure probe at each end of space differential pressure sensor locations. Probe shall have multiple sensing ports, impulse suppression chamber and airflow shielding. Provide suitable probe for indoor & outdoor locations.
- 6. Acceptable Manufacturers: Ashcroft CXLdp, Vaisala PDT10x series, or approved equivalent.

v. Building/Space Differential Air Pressure Applications (Non-Critical Applications)

- 1. The differential pressure transmitter shall use variable capacitance technology with stainless steel micor-tig welded sensor and tensioned stainless steel diaphragm and transmit a linear 0-5 VDC or 4-20 mA output in response to variation of differential pressure.
- 2. Accuracy: $\pm 2.25\%$ of span, including non-linearity, hysteresis, non-repeatability, zero offset and span setting errors.
- 3. Long-term stability: 0.5% per year
- 4. Mounting: DIN rail or standard panel mounting options
- 5. Acceptable Manufacturers: Setra 264 series, or approved equivalent.

L) BUILDING AUTOMATION SYSTEMS (BAS)

- vi.Duct Differential Air Pressure Applications (0 to 175 psi)

1. The differential pressure transmitter shall use variable capacitance technology with digital compensation and transmit a linear 0-5 VDC or 4-20 mA output in response to variation of differential pressure.

2. Accuracy: ±0.5% of span, including non-linearity, hysteresis, non- repeatability, zero offset and span setting errors.

3. Long-term stability: <0.5% per year

4. Mounting: DIN rail or standard panel mounting options

5. Acceptable Manufacturers: Ashcroft CXLdp, Vaisala PDT10x series, or approved equivalent

h. Analog Water Level Sensors

i. Furnish and install full height, analog level sensors for each location as specified. Sensor shall provide 4-20ma signal in proportion to basin water level. Provide waterproof enclosure and mounting hardware as required. Sensor shall be Drexel Brook or equal.

i. Refrigerant Monitor System

i. The unit shall meet or exceed all requirements of ANSI/ASHRAE 15 plus all local, state, and national codes.

ii. The refrigerant monitor shall be housed in a NEMA-4 wall mount enclosure as assembled by manufacturer. Detection of refrigerant vapor concentration shall be refrigerant specific and include circulation of ambient air through a non-dispersing infrared energy cell. Electro- chemical sensing technology employing depletion sensors or short term life sensors, which deplete as a normal part of their operation or storage shelf life, shall not be acceptable.

iii. Unit range of sensing shall be 0-100 parts per million (ppm) for refrigerant R-123 and/or 0-1000 ppm for all other refrigerants. Concentrations of refrigerant in the ambient air space will be displayed as PPM on the face of the monitor. The monitoring device shall indicate threshold violation via a status panel readout and remote alarm signaling.

1. Horn / Strobe / Signage

a. Refrigerant leak detection system shall include an audible and visual alarm, located directly outside of each door to the machinery room.

b. Visual alarm shall consist of a flashing yellow light placed directly over the machinery room doors with a sign that states:
DANGER – DO NOT ENTER WHEN LIGHT IS FLASHING
PELIGRO – NO ENTRAR CUANDO LA LUZ ESTE

iv.Sequential sampling and multi-point monitoring shall be employed where airflow currents and/or room size prohibit arepresentative sample from one sensing point. The system shall have add-on sample point expansion modules available for present configuration and future expansion.

v. Unit to utilize three levels of dry contact alarms to afford the following:

1. Level 1: 25 percent contamination (to energize local strobe light and audible alarm).

2. Level 2: 50 percent contamination (to energize remote alarms and area ventilating process).

3. Level 3: 100 percent contamination (to shut down all chillers in Chiller Room).

vii. The monitor shall incorporate dry contact relays for each alarm level and a malfunction relay. An analog 4-20ma signal, and an RS-485 digital output shall also be standard equipment.
- The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.
- THE UNIVERSITY OF CHICAGO FACILITIES SERVICES
- FS² Volume III - Design Requirements | Page 180

L) BUILDING AUTOMATION SYSTEMS (BAS)

j. Water Leak Detection System

i. General:

1. Furnish and install a complete water detection system for each area specified. The system shall include electronic alarm and locating modules, sensing cable, graphic maps and all auxiliary equipment. The system shall simultaneously detect the presence of water at any point along the cables length, sound an alarm and pinpoint the distance to the leak. The sensing cable shall be of such construction that no metallic parts shall be exposed to the environment. The system shall provide preconnectorized sensing cable and components. The system shall be UL listed and FM approved.
2. The system shall be as manufactured by Raychem Corporation or equal.
3. Locating leak detection panel (TTB-FA)
4. The alarm and locator module, TTB-FA, shall monitor up to a maximum of 1000 feet of sensing cable. The alarm module shall indicate that water has contacted the sensing cable by sounding an audible alarm, actuating an output relay, sending a proportional 4-20 mA signal to the BAS and displaying the distance from the start of the sensing cable to the start of the first contact with water. The location of the first water contact shall be retained on the display until the cable is dry and the module is updated.
5. The alarm module shall be capable of detecting the presence of a 1 inch leak any where along the cable with a repeatability of +/- 1%.
6. The alarm module shall continuously monitor the sensing cables and interconnecting cables for continuity. Any break in the cable shall generate an audible alarm, activate an output relay and activate a “continuity” LED on the face of the module.
7. The alarm module shall have LED’s indicating “power” (green), “alarm” (red) and “continuity” (yellow). The module shall be equipped with exposed test, reset and silence buttons. All other functions shall require key access.
8. The alarm module shall be powered by Emergency power.

9. The module enclosure shall be a minimum of 16 gauge steel, flush mounting type.

ii. Single point leak detector

1. The alarm module, TTC, shall monitor up to a maximum of 50 feet of sensing cable. The alarm module shall indicate that water has contacted the sensing cable by sounding an audible alarm and actuating an output relay. The relay shall be remain activated until the cable is dry and the module is reset.
2. The alarm module shall be capable of detecting the presence of a 1 inch leak anywhere along the cable with a repeatability of +/- 1%.
3. The alarm module shall continuously monitor the sensing cables and interconnecting cables for continuity. Any break in the cable shall generate an audible alarm, activate an output relay and activate a “continuity” LED on the face of the module.
4. The alarm module shall have LED’s indicating “power” (green), “alarm” (red) and “continuity” (yellow).
5. The alarm module shall be powered by Emergency power.
6. The module shall be mounted in an field equipment cabinet.

iii. Water sensing cable

1. The water sensing cable (TT-1000) shall detect the presence of water and pinpoint its location. The cable shall consist of four wires: Two sensor wires, a continuity wire and a return wire. All four wires shall be coated and insulated with a fluoropolymer and wound helically around a flouropolymer core. the cable shall have a breaking strength, including connectors, of at least 70 pounds, per ASTM D-638. The cable shall have an abrasion resistance of >65 cycles, per UL 719.
2. The sensing cable shall offer distributed sensing with the ability to detect the location of water at any point along the length of the cable. The cable shall be flexible, and carry less than 24VDC under normal conditions.

3. The system shall not alarm when in contact with any metallic equipment such as drip pans, floor tile supports, conduit, etc.
4. The cable shall be available in modular, preconnectorized lengths of 5, 10, 15, 25 and 50 feet. Field splicing shall not be acceptable.
5. The cable shall be UL 910 rated and plenum rated per NEC 725- 2(b).
6. Provide two sets of test instrumentation to owner.

iv. Jumper cable

1. Jumper cable shall be used where leak detection cable is not required but continuity is required (in raceways between alarm module and floor surface, etc.). The jumper cable shall be plenum rated and jacketed with fluoropolymer materials, per NEC 725-2(b). The jumper cable shall consist of four different colors (Y, B, R, G), insulated 18 AWG wires and shall be available in preconnectorized lengths of 5, 10, 15, 25 and 50 feet.

v. Accessories

1. Provide all end connectors, leader cables, hold down clips, caution tags, spray adhesive (3M 90M) as required.

vi. Graphic display map

1. Provide a graphic display map for each room served. The map shall be a 1/8 in = 1.0 ft scaled drawing of the area served, indicating actual equipment locations, floor tile and other points of reference. The actual cable routing shall be clearly marked on the map with actual scaled distances every 10 feet.
2. An dynamic graphic display, equivalent to the a forementioned map, shall be duplicated on the BAS operator workstation. The area in alarm (within 5 feet) shall blink in red until the alarm is cleared.

L) BUILDING AUTOMATION SYSTEMS (BAS)

vii. Performance

- 1. A maximum wetted area of 2 inches of cable, at any point along the entire length of cable, shall activate an alarm.
- 2. The system shall be continuously monitored for continuity. The loss of continuity shall cause an alarm within 5 seconds.
- 3. The cable shall be capable of being cleaned with a clean dry cloth, in place.
- 4. The cable shall dry and reset the module immediately upon removal from free water. No shaking, wiping or mechanical action shall be required.

viii. Installation

- 1. All system components shall be installed in accordance with the manufacturer's recommendations. The manufacturer shall provide necessary installer training and supervision as required.
- 2. The cable shall be installed on clean, dry finished surfaces only (coordinate access and schedule installation as required) after the possibility of physical damage has been eliminated. The cable shall be fastened to the surface it is monitoring every 4 feet with hold down clips and spray mastic adhesive. Hold down clip installation shall be subject to spot checks during commissioning. If any clip fails, all other clips shall be re-attached and retested, at no additional cost.
- 3. The system shall be commissioned prior to acceptance. Submit a test procedure for approval.

ix. Warranty

- 1. All equipment shall be warranted to the same extent as the BAS system, or per the manufacturer's warranty, whichever is greater.

k. Audio/Visual Alarm Units

- i. Provide 1" x 3" translucent illuminated rectangular alarm light ("BAS Alarm"), sonalert horn (hidden), silence switch with stainless steel cover plate to match desk surface. When any BAS alarm occurs (as coordinated with facilities personnel), the alarm light shall flash once per second (adjustable) and the horn shall sound. When the silence switch is pushed, the horn will silence and the pilot light shall light continuously until alarm is cleared.
- ii. The BAS shall monitor the alarm light, horn and silence switch status.
- iii. Provide 1/8 inch high engraved and painted lettering for operational instructions as required by the owner on the cover plate.

l. Fuel Oil Meters

- i. Provide fuel oil flow meter on fuel oil supply for each duplex fuel oil pump set. Meters shall be contacting head type approved for use in fuel oil systems. Monitor total accumulated flow, current flow, monthly total flow, and yearly total flow for each duplex pump set and jockey pump specified or shown.
- ii. Meter shall be intrinsically safe, explosion proof with a minimum resolution of 10 gallons with GPM range appropriate for application.

m. In-Line Flanged Electromagnetic Flow Meters for Hydronic Measurements - CHW, HHW, CW, DW:

- i. Provide an In-line flanged Electromagnetic Flow Meter complete with integral or remote electronics module. The electronics module shall include a backlit graphic display and external keypad. The principle of operation shall be based of Faraday's Law of Electromagnetic Induction.
- ii. The flow meter shall be installed in accordance with the manufacturer's installation guide including meter orientation and straight pipe recommendations. Connections to the piping shall be ANSI class 150 flanges (ANSI class 300 where required). For installations in non-metallic pipe, install grounding rings between flanges. The installing contractor is responsible for providing suitable mating flanges and any required reducer/expander.
- iii. The flow tube shall be epoxy coated steel; the sensing electrodes shall be 316SS; the liner shall be polypropylene or ebonite for low temperature service, PTFE for hot water service (266 F maximum).
- iv. Each flow meter shall be individually wet-calibrated and accurate to within ±0.2% of reading from 1.6 to 33 feet per second velocity. A certificate of calibration shall be provided with each flow meter.
- v. Output signals shall be 4-20 mA and programmable pulse. The flow meter shall be capable of measuring bi-directional flow. Each flow meter shall be factory programmed for its specific application, and shall be re-programmable using the integral keypad on the electronics module (no special interface device or computer required).
- vi. Coordinate manufacturer's recommended installation requirements with piping contractor to ensure proper installation.
- vii. Each flow meter shall be covered by the manufacturer's two-year warranty.
- viii. In-line flanged Electromagnetic Flow Meter shall be ONICON Incorporated Model F-3200, Siemens Sitrans Model MAG 6000, or as approved by the Engineer and/or BAS Department Manager.

L) BUILDING AUTOMATION SYSTEMS (BAS)

n. Energy BTU Meters

- i. The entire Energy BTU Measurement System shall be built and calibrated by a single manufacturer and shall consist of a flow meter, two temperature sensors, a BTU meter, temperature thermowells, and all required mechanical installation hardware. The BTU meter and associated sensors and flow meter shall be installed in accordance with the manufacturer’s installation guide.
- ii. The BTU meter shall provide the following points both at the integral LCD and as outputs to the building control system:
Energy Total, Energy Rate, Flow Rate, Supply Temperature and Return Temperature. Output signals shall be either serial network (protocol conforming to BACnet® MS/TP, BACnet/IP, LONWORKS®, JCI-N2, MODBUS RTU, MODBUS TCP, or Siemens-P1) and/or via individual analog and pulse outputs.
- iii. Each BTU meter shall be factory programmed and tagged for its specific application, and shall be re-programmable using the front panel keypad (no special interface device or computer required).
- iv. Temperature sensors shall be loop-powered current based (mA) sensors and shall be bath-calibrated and matched (NIST traceable) for the specific temperature range for each application. The calculated differential temperature used in the energy calculation shall be accurate to within +0.15°F (including the error from individual temperature sensors, sensor matching, input offsets, and calculations).
- v. A certificate of NIST traceable calibration shall be provided with each system.
- vi. Coordinate manufacturer’s recommended installation requirements with piping contractor to ensure proper installation.
- vii. Flow meter shall be in accordance with “In-Line Flanged Electromagnetic Flow Meters for Hydronic Measurements” paragraph above.
- viii. All equipment shall be covered by the manufacturer’s two year warranty.

- ix. Energy BTU Measurement System shall be ONICON Incorporated System-10 BTU Meter, or as approved by the Engineer.
- x. Provide isolation valve kit to allow removal and servicing of meter while system is operating.
- xi. All devices associated with the BTU meters serving the chilled water and ice storage system shall be suitable for the extreme environmental conditions. The devices shall properly operate with the specified accuracy and shall not be affected by the media, or by the environment that includes but not limited to low temperatures (10 Deg F), temperature fluctuations and condensation. Control panel enclosures and electronics shall meet the aforementioned requirements or located strategically to ensure proper operation.

o. Vortex-Shedding Flow Meters - Mass Flowmeter for Saturated Steam

- i. Furnish and install a Sierra Instruments InnovaMass 240 VTP Model Vortex Mass Flow Meter complete with integral density compensation to provide direct mass steam flow output. The flow meter shall calculate mass flow corrected for density with real time calculations based on temperature measured by an integral 1000 ohm platinum RTD. Mass flow inferred from specified steam pressure or calculated externally to the flow meter will not be acceptable. The flow meter shall measure mass flow rate, volumetric flow rate, temperature, pressure, and fluid density. The flow meter shall be sized by the manufacturer for each specific application and installed according to manufacturer’s recommendations. Provide a flow straightener, if required to meet the manufacturer’s minimum upstream straight pipe run requirement. Provide lateral and horizontal supports as required to minimize vibration at the meter location. The manufacturer shall provide a certificate of calibration for each meter. The flow meter shall be programmed by the manufacturer for each specific application and shall be ready to use upon delivery.

Mass flow accuracy shall be within ± 1.5% of actual reading over a 30:1 range, including all errors associated with velocity measurement, temperature and/or pressure measurement, and density compensation. Volumetric flow

accuracy shall be within ± 1.0% of actual reading over a 30:1 range, including all errors associated with velocity measurement, temperature and/or pressure measurement, and density compensation. The meter shall be provided with ANSI class 150 or class 300 flanges as required to meet system requirements. The maximum operating temperature shall be 750 deg F. The flow meter body shall be constructed of 300 series stainless steel and include a weather-tight NEMA-4 aluminum electronics enclosure. The meter shall display steam mass flow rate and mass flow total with an integral LCD display and support field programming of all parameters. The meter shall also have integral diagnostics to verify installation conditions and the proper operation of the meter. The meter shall provide a loop-powered 4-20 mA output signal calibrated in direct mass flow rate units for connection to the Central Control System. In addition, an integral pulse output for steam mass flow totalization shall be provided. All outputs shall be linear with mass flow rate.

- ii. Coordinate manufacturer’s recommended installation requirements with piping contractor to ensure proper installation.
- iii. Coordinate location to provide proper straight run of pipe, pipe size, etc.
- iv. Power 24VDC power supply as required from Emergency source.
- v. BAS system shall monitor mass flow rate, volumetric flow rate, total mass, temperature, pressure, and fluid density data via a serial network conforming to one of the following protocols: BACnet MS/TP, HART, MODBUS RTU .

L) BUILDING AUTOMATION SYSTEMS (BAS)

p. In-Line Makeup Water, Blowdown, and Condensate Meters:

- i. Provide an industrial-grade, field-calibratable, in-line turbine flow meter complete with integral electronics and flow computer. There will be an option for a local or remote backlit LCD display rate of flow in gallons per minute (gpm).
- ii. Wetted materials:
 1. Housing: 316 Stainless Steel
 2. Bearings: Ceramic
 3. Shaft: Tungsten Carbide
 4. Rotor: PVDF
 5. Rings: 316 Stainless Steel
- iii. The measurable flow range shall be 1 – 200 gpm with an accuracy of $\pm 1.5\%$ or better. Operating temperature range shall be 0o F to +140o F with computer. Pressure rating of 1,500 psi.
- iv. The flow meter shall be installed in accordance with the manufacturer's installation guide including meter orientation, straight pipe recommendations, and upstream filtering requirements. Connections to the piping shall be NPT or ISO (female). For installations in non-metallic pipe, install grounding rings between fittings. The installing contractor is responsible for providing suitable mating flanges or fittings and any required reducer/expander.
- v. Flow computer shall communicate instantaneous (or batch) rate of flow (which is resettable) and cumulative flow (which is non-resettable).
- vi. Meter shall be powered by lithium batteries with option for direct power connection. Batteries will have 5-year battery life.
- vii. Meter shall be the G2 model manufactured by Great Plain Industries, or approved equivalent.

q. Indoor Air Quality (CO2) Sensors

- i. Provide indoor air quality sensors to monitor Carbon Dioxide (CO2) levels.
- ii. The sensors shall utilize single-beam, dual-wavelength, non-dispersive infrared technology.
- iii. The units shall be wall or duct mounted type as indicated on plans and in the sequence of operation.
- iv. Wall mounted sensors shall be provided with white plastic cover, with optional LCD display.
- v. Duct mounted sensors shall be provided with LCD display in a dust proof plastic housing with transparent cover.
- vi. The sensor shall meet the following requirements:
 1. Operating voltage: 24 VAC/DC
 2. Accuracy: $\pm 2\%$ of range + 2% reading
 3. Power consumption: <2.5W
 4. CO2 measuring range: 0 – 2000 ppm
 5. Tolerance: ± 100 ppm
 6. Output: 4-20mA, 0 – 10 VDC
 7. Calibration: every 5 years recommended
 8. Long-term Stability: $\pm 5\%$ of range/5 years
 9. Response time: 1 minute
- vii. The sensors shall be model: Vaisala GM20 Series.

r. Continuous Air Quality Monitors, if installed, should be RESET Accredited. These sensors should not control building systems, but be connected to the BAS for data collection, storage, and analysis.

s. Relays.

- i. Control relays shall be UL listed plug-in type with dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
- ii. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable $\pm 200\%$ (minimum) from set point shown on plans. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.

- iii. Where required, provide “delay on break” relays where the output remains energized for the pre-determined time delay after the input has been de-energized. Reclosing the input switch during timing resets the time delay. Loss of input voltage resets the time delay as well as the output.

t. Override Timers.

- i. Override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration as required by application. Provide 0-to- 6-hour calibrated dial unless otherwise specified. Timer shall be suitable for flush mounting on control panel face and located on local control panels or where shown.
- ii. Current transmitters.
- iii. AC current transmitters shall be the self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4 to 20 mA two-wire output. Unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A full scale, with internal zero and span adjustment and $\pm 1\%$ full-scale accuracy at 500 ohm maximum burden.
- iv. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA Recognized.
- v. Unit shall be split-core type for clamp-on installation on existing wiring.

u. Current Transformers.

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

L) BUILDING AUTOMATION SYSTEMS (BAS)

v. Voltage Transmitters.

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

w. Voltage Transformers.

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

x. Power Monitors.

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

y. Current Switches.

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

z. Pressure-Electric (Pe) Switches.

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

aa. Electro-Pneumatic (E/P) Transducers.

- i. Electronic/pneumatic transducer shall provide a proportional 20 to 100 kPa (3 to 15 psig) output signal from either a 4 to 20 mA or 0 to 10 VDC analog control input.
- ii. E/P transducer shall be equipped with the following features:
 - 1. Separate span and zero adjustments
 - 2. Manual output adjustments
- iii. Pressure gauge assembly d. Feedback loop control
- iv. Air consumption of 0.05 L/s (0.1 scfm) at mid-range

bb. Local Control Panels.

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

cc. Room Pressure Monitor:

- i. General:
 - 1. The room pressure monitor shall be CRC-RPM model as manufactured by Critical Room Control (CRC).
 - 2. CRC-RPM1: Monitor the pressure of one pressure relationship.
 - 3. CRC-RPM2: Monitor the pressure of two pressure relationships.
 - 4. The room pressure monitor shall be capable of monitoring up to two (2) differential pressure relationships. Each monitor shall have its own controller capable of standalone operation. Each monitor is capable of both visual and audible alarms. Each monitor will use direct pressure measurement utilizing industrial quality differential pressure transducer technology. Pressure sensing technology shall be a dead ended non-metallic silicon diaphragm that does not allow air/gas to pass from controlled space to reference. The monitor shall be capable of displaying pressure to 0.0001” WC.
 - a. Implied pressure measurement systems utilizing thermal hot wire or thermal mass air velocity measurement are not acceptable.
 - 5. Each monitor shall have an easy to navigate microprocessor based controller with full color touch screen interface. Minimum touch screen size to be 4.0”. Screen shall be capable of displaying multiple colors at the same time. Monitor shall not be limited to single screen size and shall be available in multiple sizes depending on application. All settings and programming shall be made via simple touch screen or communication network. The monitor shall have a full color LED TFT/ WQVGA touch screen with a minimum resolution of 480 X 272 (WQVGA), 16 bit (65,535) color depth and sunlight viewable. Panel shall have a minimum brightness rating of 350 cdm for clear indication in all lighting environments. Each monitor shall incorporate a high speed microprocessor based controller, designed for critical environment control applications.

L) BUILDING AUTOMATION SYSTEMS (BAS)

- 6. The monitor shall have easy to navigate screens that clearly give the user description of any changes that are being made.
 - a. Displays that simply change the back lighting for color or use LED indicators are not acceptable.
 - b. Monitors that use keypads and layered menus are not acceptable.
- 7. Display shall be user programmable with graphics and verbiage included with monitor. Monitor shall store all settings in a non-volatile memory. Monitor will allow user to continually display or hide room differential pressure. Main screen shall be solely reserved for critical information and not display programming or menu information. Monitor settings shall be accessed via dual password protected touch screen. Main display shall allow user to select from at least three (3) colors. Monitor shall include automated room changeover including timed clearing and cleaning modes. The monitor shall display the values and setpoints of at least eight (8) auxiliary points in addition to differential pressure. The monitor shall include both visual and audible alarming of both differential pressure and auxiliary points. The monitor shall be field configurable to allow or not allow user to make adjustments setpoints.
- 8. The monitor shall include at least five (5) modes. Modes shall allow for user to enter customizable naming. Monitor shall display user defined precautions. Precautions shall be field customizable.
- 9. Monitor shall be recess or surface mounted. Supply voltage shall be 24 VDC.
 - a. Monitors using single or multiple line LCD alphanumeric character displays, LED indicators or backlit screens are not acceptable. Touch pads and layered programming menus are not acceptable.
- 10. Screen is capable of wipe down cleaning and water spray and dust resistant meeting (IP-54).

- ii. Mounting:
 - 1. Monitors shall be mounted outside of controlled space at locations shown on the prints. The monitors shall be mounted in locations that are easily visible and accessible by staff.
 - 2. The room monitor shall be available in both recessed and surface mounting configurations.
 - 3. The monitors shall not require penetration into the wall for mounting. The monitor shall not extend more than 0.75" from the wall.
 - 4. Monitors that require differential pressure lines to be run down the wall to monitor must be copper or stainless steel to eliminate kinking.
- iii. Room monitor:
 - 1. The monitor shall use clear unambiguous screen and verbiage to indicate monitor modes and alarms. The main display shall clearly indicate the current status of up to two (2) pressure relationships. The main screen shall allow user to display or not display actual differential pressure. The ability to show and hide actual differential pressure readout shall be accessed from the main screen without having to reconfigure monitor. The monitor shall display the current user defined precautions without having to reconfigure monitor. The monitor shall display current user defined precautions for entering the space. All pressure relationships and associated differential pressure relationships must be clearly displayed at all times.
 - 2. Monitor shall allow the user to select the background color for the main screen.
 - a. The monitors that change main screen or scroll to display additional relationships are not acceptable. Actual pressure readout must be able to be accessed from the main screen without having to reconfigure monitor.

- iv. Modes:
 - 1. The monitor shall have a minimum of five (5) user defined modes. Each mode shall be capable of field configuration and naming. The monitor shall include automated sequences and timing features for procedures and room changeover.
 - 2. Naming of the modes shall be field configurable through the touch screen interface. The modes shall include functionality associated with:
 - a. Isolation/pressure controlled.
 - b. Isolation alarming.
 - c. Occupied non-isolation.
 - d. Clearing of space.
 - e. And cleaning.
 - 3. Mode change shall include optional password protection.
 - 4. All modes shall be capable of automating proper procedures. The modes shall include user selectable timed procedures and staff interaction functions.
 - a. Monitors that allow users to select from fixed verbiage or banners that are not coupled to proper sequencing or logic are not acceptable. All mode changes shall be able to be password protected. Each mode will have unique parameters and screen graphics clearly indicating changed status. Mode and condition of space shall be made with single user change and not require user to make changes to multiple parameters.
 - b. Monitors that do not offer automated function of clearing, cleaning and room changeover are not acceptable.

L) BUILDING AUTOMATION SYSTEMS (BAS)

v. Precautions:

- 1. The monitor/controller shall include precautions that can be displayed during occupied modes. Precautions shall be selected and automated with modes. The user selected precaution shall be clearly shown on the main screen. The monitor shall be capable of not showing any precautions if current conditions do not require any special safety requirements. Precautions shall be automated with current mode selected.
- 2. Changes to precautions shall include optional password protection.
 - a. Monitors that do not integrate and/or automate displaying precautions with mode selection or require user to reconfigure or manual key in verbiage are not acceptable.

vi. More information:

- 1. Each monitor shall have a dedicated screen capable of displaying up to eight (8) network points. The “more information” screen shall be accessible from the main screen.
- 2. Each point shall be field configurable for type/name i.e. “temperature, humidity, air change rate, etc.” Each point shall be field configurable to engineering units i.e. °F, °C, WC, etc.”
- 3. Each point shall allow user to select the appropriate resolution to be displayed. Each point shall:
 - a. Display status of point.
 - b. Include audible and visual alarming of point.
 - c. Display or not display set point.
 - d. Allow or not allow user to make set point change.

vii. Pressure sensing:

- 1. The room pressure monitor shall be capable of monitoring up to two (2) differential pressure relationships. The monitor pressure sensing shall continuously monitor bi-directional room pressure and the associated referenced space. Each monitor will use direct pressure measurement utilizing industrial quality differential pressure transducer technology. Pressure sensing technology shall be a dead ended non-metallic diaphragm that does not allow air/gasto pass from controlled space to reference space. Pressure measurement shall use a variable capacitance sensor. Each sensor shall be digitally compensated using an application specific integrated circuit (ASIC).
- 2. Pressure sensor shall not be limited to monitor and field removable. The pressure sensor shall be capable of replacement without removing monitor. The pressure sensor shall be capable of changing ranges without removing monitor. Pressure sensing operation shall be indicated by integral LED power/status light.
- 3. Pressure sensor shall be individually calibrated for installed and scheduled range.
- 4. The room pressure sensing shall be factory calibrated with NIST traceable standards.
 - a. Implied pressure measurement systems utilizing thermal hot wire, thermal mass air velocity measurement, metallic diaphragm or non-dead ended are not acceptable.
 - b. Pressure sensors that catalogue accuracy based on larger transducer ranges will not be accepted.
 - c. Monitor suppliers with pressure sensing integral to monitor shall include one (1) monitor/sensor for every five (5) monitors required for project.

viii. Accuracy:

- 1. Sensing accuracy shall be ±0.4% or ±0.8% full scale including the effects of non-linearity, non-repeatability, hysteresis, zero offset and span setting errors.
 - a. All monitors must supply differential pressure sensor accuracy statements that include the effects of non-linearity, hysteresis, non-repeatability, zero offset and span setting errors.
 - b. Accuracy statement sand claims that use the (RSS) root sum squares of non-linearity (BFSL), non-repeatability and hysteresis or exclude zero offset and span setting errors are not acceptable.
- 2. Stability: Stability per year shall ≤0.25% per year.
- 3. Overpressure limits: Minimum proof pressure of 15 psi and minimum.
- 4. Burst pressure limits: Minimum burst pressure of 25 psi.
- 5. Available pressure ranges: The monitor shall support the following pressure ranges:
 - a. 0/0.1, 0/0.25, 0/0.5, 0/0.75, 0/1.0, 0/2.0, 0/2.5, 0/3.0, 0/5.0, 0/10.0, 25.0.
 - b. Compound: ±0.1, ±0.25, ±0.5, ±1.0, ±2.0, ±5.0, ±10.0.

ix. Pressure sensor setup:

- 1. The monitor shall be field configurable to accept multiple signal inputs. The monitor shall accept a hardwired analog signal or network signal.
- 2. The monitor shall be field configurable to accept multiple pressure ranges. The monitor shall be capable of accepting multiple input signals of (4-20mA, 0-5V or 0-10V). The monitor shall allow the users to zero calibrate pressure without removing monitor or accessing pressure transducer. Zero function shall be accomplished via room monitor touch screen. The monitor shall display offset of zero calibration. The offset shall be directly field configurable without calibration function.
- 3. The monitor shall be able to display in inches of water (“WC) or Pascal’s (pa).

L) BUILDING AUTOMATION SYSTEMS (BAS)

- x. Alarms (audible and visual):
 - 1. Audible alarms:
 - a. The monitor shall include at least three (3) distinct alarm sounds. Alarms shall include:
 - i. Pressure alarm.
 - ii. Remote alarm.
 - iii. More info auxiliary alarm.
 - b. Pressure: The monitor shall include both high and low alarms. Both high and low alarms shall be individually configurable. The monitor shall allow for disabling the audible alarm. The monitor shall allow for programmable audible alarm time delay. The monitor shall be capable of locally and remotely acknowledging the audible alarm. The monitor shall include an acknowledgement time out feature. The acknowledgement time out features silences the audible alarm for user defined time, if alarm condition is not cleared after acknowledgement time period has expired the audible alarm will rest. The acknowledge time out feature shall allow for field configurable time delay or can be disabled. Audible alarm shall be indicated with unique icon appearing on the screen. The alarm icon shall also indicate when alarm has been acknowledged.
 - c. More information: Audible alarms shall be configurable for each of the eight (8) “more info” points. Alarms shall be able to be locally and remotely silenced. When silenced, the monitor shall visually indicate that the alarm has been silenced. When point being displayed does not have any alarm parameters, the indicator shall be grey. When audible alarm has been acknowledged, the indicator will show that alarm has been acknowledged.

- 2. Visual alarms:
 - a. Pressure: The monitor shall at all times display current condition and alarm status of all pressure relationships being monitored. If monitor is configured for two pressure relationships, both relationships must be clearly displayed at all times. All pressure alarms must be clearly displayed whenever in pressurized mode. When pressure is not being maintained and inside the timed audible delay period, the monitor screen shall display “loss of pressure” and change indication to amber. The monitor shall include a unique “loss of pressure” icon and verbiage indicating that the differential pressure is outside of designated pressure ranges. When pressure is outside of alarm pressure range and audible delay is not active or delay has elapsed, the monitor shall display “pressure alarm” and change indication to red. The monitor shall include a unique alarm icon and verbiage indicating that the differential pressure is outside of designated pressure ranges. Whenever “loss of pressure” or “pressure alarm” conditions are present, the monitor shall also prompt user to check door.
 - i. Monitors that change main screen or scroll to display additional relationships and alarms are not acceptable.
 - ii. Monitor/controllers that do not specifically indicate status or rely on ambiguous verbiage similar to “caution” are not acceptable.
 - b. More information: Each point shown on the “More Info” screen shall have individual indication for current point status. When no alarm is present, the status indicator shall be green. When in alarm status, indicator shall be red. When point being displayed does not have any alarm parameters, the indicator shall be grey. When audible alarm has been acknowledged, the indicator shall show that alarm has been acknowledged.

- xi. Door contact (optional):
 - 1. The monitor shall be capable of supporting multiple door contacts. The door contact shall be stand alone or integral to pressure control logic and sequencing.
 - 2. The monitor shall support surface mount, recessed mount, overhead door, plunger, disconnect and magnet style door contacts.
 - 3. Door contact shall be field configurable to allow the user option to “freeze” the monitor pressure control PI loop.
 - 4. Door control logic to include:
 - a. Door closed and pressure is lost: Monitor to bypass “loss of pressure” mode and go directly “pressure alarm” mode.
 - b. Door open and pressure is lost: Monitor indicates “loss of pressure” mode for alarm delay period. When alarm delay has timed out the monitor will go to “pressure alarm” mode.
- xii. Monitor inputs and outputs:
 - 1. The monitor shall have minimum of the following inputs and outputs:
 - a. Analog inputs: Four (4) analog inputs.
 - b. Analog outputs: Four (4) analog outputs.
 - c. Digital inputs: Four (4) digital inputs.
 - d. Digital contacts: Four (4) digital contacts (relay).
 - 2. The monitor shall include onboard power isolation.
 - 3. The monitor shall include LED light indicators that monitor is powered and working properly.
 - 4. The monitor shall include on board power supply including:
 - a. 10 vdc.
 - b. 5 vdc.
 - c. Power circuit for 4-20mA.

L) BUILDING AUTOMATION SYSTEMS (BAS)

xiii. Power isolation:

- 1. The monitor shall be powered by 24 VAC. The pressure monitor shall be internally isolated and not require external isolation transformers.
 - a. Monitors that require isolated power supplies shall be responsible for providing proper isolation transformers with hinged enclosure and manual disconnect. The cost for installing isolated power supplies shall be included in monitor price.

xiv. Network communication:

- 1. The monitor shall have an RS-485 serial network interface that supports native BACnet MS/TP. The monitor shall also support Modbus, N2 and Lon with optional card.
- 2. All network configurations shall be made without removing monitor from the wall or mounting location.
- 3. All network parameters shall be digitally set via touch screen interface. The monitor network shall be field configurable from the touch screen administrative menu.
- 4. The monitor shall support baud rates of 9600, 19200, 38400, 56200, 76800 and 115200.
- 5. The monitor shall support instance ID's of a minimum 1-4,000,000.

xv. Analog communication:

- 1. The monitor shall be capable of communicating via non-network analog points.
- 2. A minimum of four (4) relays shall be available for pressure alarm indication.
- 3. The monitor shall be able to send analog signal of modechange between multiple monitors without the use of a communication network.
- 4. The monitor shall be able to send and receive analog differential pressures between unlimited monitor/ controllers in a daisy chain configuration without the use of a communication network.
- 5. The monitor shall be able to send analog signal and/ or relay contacts for communication with remote monitoring station without the use of a communication network.
 - a. Monitors that require differential pressure and alarms to be passed to remote monitor and between multiple monitors shall be required to run redundant independent communication networks.

xvi. Password protection:

- 1. Monitor shall have at least two layers of passwords:
 - a. Staff password shall allow access to daily functions and mode selection.
 - b. Administrative password shall allow access to engineering and monitor configuration screens.
- 2. The staff password shall be able to be deactivated.
- 3. Staff password shall be able to be changed from the administrative menu.
- 4. The monitor shall have a unique password for staff use and a separate unique password for the accessing the administrative menu.
 - a. Monitors that give access to menus while unit is inoperation or do not offer separate passwords for staff and administrative functions will not be accepted.
 - b. All menus shall be hidden from view and only appear when screen is touched. Monitors that only use a single level of password protection are not acceptable.

xvii. Time out feature: The monitor shall have a time out feature. This feature shall return the monitor to the main screen after inactivity (field configurable).

xviii. Watchdog function: The monitor shall continuously monitor its own operation to ensure that it is operating properly. The monitor shall be capable of resetting itself to clear any errors before notification.

xix. Diagnostic screen:

- 1. The monitor shall graphically show all analog and digital inputs and outputs.
- 2. Analog inputs shall be shown on a bar indicating 0-100% of full signal.
- 3. The diagnostic screen shall allow for testing of parameters and system checkout without removal of monitor.
- 4. Digital inputs shall be indicated as red or green as follows:
 - a. Open verbiage with green indication.
 - b. Shut verbiage with red indication.
- 5. Analog outputs shall be able to be controlled from this screen. The user shall be able to move the outputs from 0-100% signal. The monitor shall send same signal of field components.
- 6. Allows the user to open and close controller relays as follows:
 - a. Open verbiage with gray indication.
 - b. Shut verbiage with red indication.
 - c. Monitors that do not have I/O diagnostics shall include costs for factory representative on site for any troubleshooting that may be related to I/O for installed locations.

L) BUILDING AUTOMATION SYSTEMS (BAS)

dd. User Interface Touch Screen Display:

i. General:

1. The room user interface shall be CRC-Multiview Model as manufactured by Critical Room Control (CRC).
2. The Multiview shall be capable of displaying up to six (6) fully configurable environmental point values, room status or mode selection graphical icons. Graphical icons shall be displayed in up to seven (7) different arrangements. Each icon shall be configurable to include the point's title, current value, set point, status and/or mode. Multiview shall be able to display any combination of graphical icons on the same screen.
3. Multiview points shall include individual alarm parameters for each point. The Multiview shall be capable of displaying current point values, set points, point status, mode and alarm parameters. Multiview shall allow for user to make set point, status or mode changes. Each monitor is capable of both visual and audible alarms. Each Multiview monitor will support direct and network capabilities. The Multiview graphical icons shall be individually color configurable.
4. Each Multiview shall have an easy to navigate microprocessor based controller with full color touch screen interface. Minimum touch screen size to be 7.0". Screen shall be capable of displaying multiple colors at the same time. Monitor/controller shall not be limited to single screen size and shall be available in multiple sizes depending on application. All settings and programming shall be made via simple touch screen or communication network. All settings and programming shall be made via simple touch screen or communication network. The monitor shall have a full color LED TFT / WQVGA touch display with a minimum resolution of 800 X 480 (WVGA), 18 bit (262,144) color depth, and sunlight viewable. Panel shall have a minimum brightness rating of 400cdm for clear indication in all lighting environments. Each Monitor shall incorporate a high speed microprocessor based controller, designed for critical environment control applications.

5. Each monitor shall be capable of accepting point information via direct analog signal or from network communication.
6. The monitor shall have easy to navigate screens that clearly give the user description of any changes that are being made:
 - a. Displays that simply change the back lighting for color or use LED indicators are not acceptable.
 - b. Monitors that use keypads and layered menus are not acceptable.
7. Display shall be user programmable with graphics and verbiage included with monitor. The Multiview shall store all settings in non volatile memory. The Multiview shall allow the user to continually display up to six (6) user configurable point values, point status or modes. Main screen shall be solely reserved for critical information and not display programming or menu information. Multiview shall be accessed via optional password protected touch screen. The Multiview shall include both visual and audible alarming. The Multiview shall be field configurable to allow or not allow user to make adjustments set points, current status and mode change.
8. Monitor shall be recess or surfacemounted. Supply voltage shall be 24 VAC/DC.
9. Monitor shall be recess or surface mounted. Supply voltage shall be 24 VAC/DC.

ii. Mounting:

1. The Multiview shall be mounted at locations shown on the prints. The Multiview shall be mounted in locations that are easily visible and accessible by staff.
2. The Multiview shall be available in both recessed and surface mounting configurations.
3. The Multiview shall not require penetration into the wall for mounting. The monitor shall not extend more than 0.75" from the wall.
4. Controller shall be mounted remote from the monitor. All control wiring shall be connected to the controller located remote from monitor.

iii. Multiview value points:

1. The Multiview shall use clear unambiguous screen and verbiage to indicate current values and alarms.
2. The main screen shall display up to six (6) graphical icons. The monitor shall be field configurable to support between 1-6 graphical icons.
3. Each point on the main screen shall display points and associated set points. Each point shall be configurable to allow or not allow user to adjust set point.
4. Each point's status shall be indicated by color background. If a room goes into alarm, its background will turn red, an audible alarm will sound, and a alarm icon will appear. A user can silence the audible alarm via a "Silence Alarm" button located on each graphical icon. If a user acknowledges / silences a room's audible alarm, that room's background will remain red until the alarm condition changes to normal. Each value point shall be configurable as an analog or network input/output.

iv. Multiview list/status points:

1. The Multiview shall use clear and unambiguous screen and verbiage to indicate a list of user selectable status points.
2. The main screen shall display up to six (6) graphical icons. The monitor shall be field configurable to support between 1-6 graphical icons.
3. Points shall be fully configurable to change modes, indicate alarms, perform control sequencing etc. The Multiview shall be configurable for up to thirty (30) status points.
4. Each graphical icon list shall allow the user to indicate visual and audible alarms based on selection. A user can silence the audible alarm by via a "Silence Alarm" button located on each graphical icon. Each list point shall color configurable. Each value point shall be configurable as an analog or network input/output.

L) BUILDING AUTOMATION SYSTEMS (BAS)

- v. Multiview mode points:
 - 1. The Multiview shall use clear and unambiguous screen and verbiage to indicate a list of user selectable status points.
 - 2. Each graphical icon shall be field configurable to allow up to 1-5 user defined modes.
 - 3. The Multiview shall be configurable for up to thirty (30) modes.
 - 4. Points shall indicate alarms, perform control sequencing etc.
 - 5. Each graphical icon list shall allow the user to indicate visual and audible alarms based on selection. A user can silence the audible alarm via a “Silence Alarm” button located on each graphical icon. Each mode shall be color coded and field configurable. Each mode point shall be configurable as an analog or network input/output.
- vi. Alarms:
 - 1. The Multiview shall have both audible and visual alarm thresholds:
 - 1) Alarm range high and low shall be active when point values exceed the alarm parameters. The background color of the point shall change and indicate alarm condition. A user can silence the audible alarm by via a “silence alarm” button located on each graphical icon.
 - 2. The Multiview shall include both high and low alarms. Both high and low alarms shall be individually configurable.
 - 3. The Multiview shall allow for disabling the audible alarm. The Multiview shall allow for programmable audible alarm time delay. The Multiview shall be capable of locally and remotely acknowledging the audible alarm. Audible alarm shall be indicated with unique icon appearing on the main screen graphical icon. The alarm Icon shall also indicate when alarm has been acknowledged.
 - 4. The Multiview shall allow user to set up both audible and visual alarms based on point status. Status alarms shall be field configurable for both color and alarm.

- 5. The Multiview shall allow user to set up both audible andvisual alarms based on point mode. Status alarms shall be field configurable for both color and alarm.
- vii. Multiview set point change:

The Multiview shall be field configurable to display current setpoint and allow access to make local changes to set point. Set point change shall be accessed from the main screen graphical icon.
- viii. Multiview status change:

The Multiview shall be field configurable to display current status and allow access to make local changes to status point. Status change shall be accessed from the main screen graphical icon.
- ix. Multiview mode change:

The Multiview shall be field configurable to display current mode and allow access to make local changes to modes. Mode change shall be accessed from the main screen graphical icon.
- x. Controller inputs and outputs:
 - 1. The monitor/controller shall have minimum of the following inputs and outputs:
 - a. Analog inputs: Four (4) analog inputs.
 - b. Analog outputs: Four (4) analog outputs.
 - c. Digital inputs: Four (4) digital inputs.
 - d. Digital outputs: Four (4) digital outputs.
 - 2. The controller shall include on board power isolation.
 - 3. The controller shall include LED light indicators that controller is powered and working properly.
 - 4. The controller shall include on board power supply including:
 - a. 10 vdc.
 - b. 5 vdc.
 - c. Power circuit for 4-20 mA.

- xi. Power isolation:
 - 1. The monitor shall be powered by 24VAC/DC. The pressure monitor/controller shall be internally isolated and not require external isolation transformers.
 - a. Monitors that require isolated power supplies shall be responsible for providing proper isolation transformers with hinged enclosure and manual disconnect. The cost for installing isolated power supplies shall be included in monitor price.
- xii. Network communication:
 - 1. The Multiview shall have an RS-485 serial network interface that supports native BACnet MS/TP. The monitor/controller shall also support Modbus, N2 and Lon with optional card.
 - 2. All network configurations shall be made without removing controller from the wall or mounting location.
 - 3. All network parameters shall be digitally set via touch screen interface. The monitor/controller network shall be field configurable from the touch screen administrative menu.
 - 4. The controller/monitor shall support baud rates of 9600, 19200, 38400, 56200 76800 and 115200. The controller/monitor shall support instance ID’s of a minimum of 1-4,000,000.

L) BUILDING AUTOMATION SYSTEMS (BAS)

xiii. Analog communication:

- 1. The monitor/controller shall be capable of communicating via non- network analog points. The monitor/controller shall send analog signals mirroring associated analog inputs.
- 2. A minimum of four (4) relays shall be available for alarm, status or mode indication.
- 3. A minimum of four (4) analog outputs shall be configurable for relaying inputs, communicating set point, status or modes.
- 4. A minimum of four (4) configurable analog inputs. Inputs shall support analog signals from remote sensors and controllers. Inputs can be configured as a value, mode or status input. The inputs shall be configurable to accept multiple voltage inputs.
- 5. A minimum of four (4) digital inputs shall be available for alarms, status and mode changes from other monitors, relays or controllers.
- 6. The monitor/controller shall be able send analog signal and/ or relay contacts for communication with remote monitoring station without the use of a communication network.

xiv. Password protection:

- 1. Monitor/Controller shall have at least one (1) password. The password shall be field configurable. User shall be able to activate or deactivate password protection.
- 2. The monitor shall have a time out feature. This feature shall return the monitor to the main screen after inactivity (field configurable). After timeout screen will require user to re-enter password to make changes.
 - 1) Monitors that give access to menus while unit is in operation or do not offer separate passwords for staff and administrative functions will not be accepted.
 - 2) All menus shall be hidden from view and only appear when screen is touched.

xv. Watchdog function:

- 1. The Monitor/controller shall continuously monitor its own operation to ensure that it is operating properly. The monitor/controller shall be capable of resetting itself to clear any errors before notification.

xvi. Diagnostic screen:

- 1. The monitor/controller shall graphically show all analog and digital inputs and outputs.
- 2. Analog inputs shall be shown on a bar indicating 0-100% of full signal.
- 3. The diagnostic screen shall allow for testing of parameters and system checkout without removal of monitor/ controller.
- 4. Digital inputs shall be indicated as red or green as follows:
 - 1) Open verbiage with green indication.
 - 2) Shut verbiage with red indication.
- 5. Analog outputs shall be able to be controlled from this screen. The user shall be able to move the outputs from 0-100% signal. The controller shall send same signal to field components.
- 6. Allows the user to open and close controller relays as follows:
 - 1) Open verbiage with gray indication.
 - 2) Shut verbiage with red indication.

ee. Differential Pressure Monitor:

- i. Differential pressure monitor for space pressure differentials in Surgeries, Isolation Rooms, etc., to be TSI Pressura Model #8630-PM with adjustable update to negate rapid alarm change.
- ii. Unit to include alphanumeric digital display of room pressure differential in inches water gage.
- iii. Alarm to be initiated with an adjustable 20-600 second delay any time the room pressure differential is less than 0.05” wg.
- iv. The monitor system shall include sensor, digital interface module, transformer, cables, and a Mute menu key to manually deactivate the audible alarm for 5-minute intervals and then require reset for additional deactivation period.
- v. Differential Pressure Room Pressure Switch equal to TSI Model #8694-7 with Negative-Neutral key switch and alarm status lights. The key switch will deactivate all alarms when in the Neutral position. All alarms will be active when the key switch is in the Negative position.

ff. Local User Display

- i. Where specified in the sequence of operation or points list, the controllers on the peer to peer building level network shall have a display and keypad for local interface. A keypad shall be provided for interrogating and commanding points in the controller.
- ii. The display shall use the same security password and access rights for points in the display as is used in the associated controller.
- iii. The LCD display shall be a minimum of a 2 line 40 character display.
- iv. The LCD display shall include the full point name, value (numeric, digital or state text), point priority and alarm status on one screen.
- v. The LCD shall dynamically update the value, priority, and alarm status for the point being displayed.
- vi. The display shall be mounted either on the door of the enclosure or remote from the controller.

L) BUILDING AUTOMATION SYSTEMS (BAS)

13. COMMUNICATION AND CONTROL WIRING

- a. General:
 - i. Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of Division 16 unless otherwise noted herein.
 - ii. All insulated wire to be copper conductors, UL labeled for 90°C minimum service.
- b. Wire Sizing and Insulation
 - i. Wiring shall comply with minimum wire size and insulation based on services listed below:
 - 1. Service Minimum Gage/Type Insulation Class
 - 2. AC 24V Power 12 Ga Solid 600 Volt
 - 3. DC 24V Power 10 Ga Solid 600 Volt
 - 4. Class 1 14 Ga Stranded 600 Volt
 - 5. Class 2 18 Ga Stranded 300 Volt
 - 6. Class 3 18 Ga Stranded 300 Volt
 - ii. Provide plenum-rated cable when open cable is permitted insupply or return air plenum where allowed per execution specifications defined in Paragraph 3.07
- c. Power Wiring:
 - i. 115V power circuit wiring above 100 feet distance shall use minimum 10 gage.
 - ii. 24V control power wiring above 200 feet distance shall use minimum 12 gage.
- d. Control Wiring:
 - i. Digital Input/output wiring shall use Class 2 twisted pair, insulated.
 - ii. Analog inputs shall use Class 2 twisted shielded pair, insulated and jacketed and require a grounded shield.
 - iii. Actuators with tri-state control shall use 3 conductor with same characteristics

- e. Communication Wiring
 - i. Ethernet Cable shall be minimum CAT5
 - ii. Secondary level network shall be 18-24 gage, TSP, low capacitance cable
- f. Approved Cable Manufacturers:
 - i. Wiring from the following manufacturers which meet the above criteria shall be acceptable:
 - 1. Anixter
 - 2. Belden

14. FIBER OPTIC CABLE SYSTEM

- a. Refer to the University of Chicago IT Services Standards.

L) BUILDING AUTOMATION SYSTEMS (BAS)

15. DATA INFORMATION / CONNECTION OUTLET

- a. The installation of data information outlets is mandatory for all new and renovated University buildings in order to comply with industry standards and provide the University with a consistent and sustainable infrastructure.
- b. For those buildings served and supported by the University of Chicago IT Services (ITS), the ITS Department is responsible for installing all fiber optic cables, patch panels, Category 6A Ethernet cables, routers, switches, and network outlets or “drops” – including network data “drops” required for the BAS system. The University’s Project Manager submits a request for the necessary network data “drops” to the ITS Department. After installation, the BAS Department requests activation of respective data “drops” through the ITS Department.
- c. For buildings not served and supported by the ITS Department, ITS is responsible for installing the fiber optic cable to the building and terminating it at the main patch panel. Beyond that point, the BAS contractor is responsible for furnishing and installing the Category 6A Ethernet cable, network switches and routers, and network data “drops” required for the BAS system. Refer to the University of Chicago IT Services Standards for network hardware requirements. The BAS Contractor shall follow the installation requirements as stated below:
 - 1. Ethernet cable shall be Commscope Uniprise Category 6A, non-plenum, 4-pair cable supporting 10GB/s Ethernet requirements.
 - 2. At the IDF end, the cable will be terminated at a Category 6A RJ45 Uniprise patch panel.
 - 3. Each data outlet shall have two Category 6A cables installed. One white cable and one gray cable.
 - 4. At the data outlet end, the cable will be terminated at Category 6A 8- position 568B/RJ45 jacks, gray in color, and terminated in a 2-port face plate

- 5. Horizontal face plate configuration:
 - a. In a 2-port face plate, the “C1” data jack (first, white cable) shall be in the bottom position and the “C2” data jack (second, gray cable) shall be in the top position.
 - b. In a 4-port face plate, the “C1” data jack shall be in the bottom left position, the “C2” data jack shall be in the top left position, the “C3” data jack shall be in the bottom right position, and the “C4” data jack shall be in the top right position.
- 6. Vertical face plate configuration:
 - a. In a 2-port face plate, the “C1” data jack (first, white cable) shall be in the left position and the “C2” data jack (second, gray cable) shall be in the right position.
 - b. In a 4-port face plate, the “C1” data jack shall be in the top left position, the “C2” data jack shall be in the top right position, the “C3” data jack shall be in the bottom left position, and the “C4” data jack shall be in the bottom right position.
- 7. All cable will be secured and dressed with Velcro tie-wraps.
- 8. Do not install compressed, kinked, scored, deformed, or abraded cable. If any cable is, or becomes damaged, replace the entire length of damaged cable.
- 9. All data outlets shall be serviced with 1” conduit to the basket tray, or pull box via horizontal conduit system. Conduits shall service only one data outlet each. No daisy-chaining or looping between data outlets is allowed.
- 10. Labeling:
 - a. For vertical face plates, the location labels shall be installed on the top label holder on the face plate.
 - b. For horizontal face plates, the location labels shall be installed on the left label holder on the face plate.
 - c. For vertical face plates, the IDF labels shall be installed on the bottom label holder on the face plate. This label will contain the IDF room number only.
 - d. For horizontal face plates, the location labels shall be installed on the right label holder on the face plate. This label will contain the IDF room number only.

16. REFERENCES

- The Consultant shall comply with the following codes and standards:
- Current City of Chicago Building Code, including mechanical, plumbing, fire protection, and energy codes.
 - ASHRAE standards including ASHRAE 55, ASHRAE 62.1, and ASHRAE 90.1
 - All state codes
 - FM Global Property Loss Prevention Data Sheets and approved products as applicable.

M) ELECTRICAL SYSTEMS

1. INTRODUCTION

The following Electrical Systems Standards provide requirements and guidelines for use by the Consultant in the design and construction of electrical systems at the University of Chicago. The Standards are not intended to be used as a specification or in place of a specification. These standards exist as a program document and are not intended to be a contract document. The information in the Standards is not meant to replace professional design analyses and does not relieve the Consultant of any professional or contractual responsibility. Consultants are expected to conduct independent evaluations and to discuss recommendations with the project manager and associated professional staff. Refer questions and comments regarding the content and use of this document to the University FS Project Manager.

a. General Design Requirements

- 1. In general, Consultant is to design systems considering sustainable items such as regional manufacturers, recycled / American steel and copper and manufacturer’s use of low VOC coatings.
- 2. All electrical systems shall be designed and specified as “Fully-rated” systems. “Series- rated” systems are not acceptable.
- 3. It is expected that the project design follow all applicable FM Global Property Loss Prevention Data Sheets (Engineering Guidelines). The FS Project Manager will coordinate the review of system designs with FM Global.
- 4. On completion of installation, including outlets, fittings and devices, inspect exposed finish. Remove burrs, dirt, paint spots and construction debris.
- 5. Protect equipment and installations and maintain condition to ensure that coatings, finishes and cabinets are without damage or deterioration at time of Substantial Completion.
- 6. All VFD driven motors shall employ sustainable motor design to prevent bearing failure. All VFD driven motors will be designed to employ induced voltage bearing current mitigation strategies using shaft ground ring technology, isolated bearing, insulated coupling, etc.

b. University Adopted Naming Convention for Panelboards, Switchboards and Equipment.

- 1. The panel designation can be up to five (5) characters, last character separated by a hyphen.
- 2. Position One – Source
 - a. N – Normal
 - b. C – Critical Branch
 - c. S – Life Safety Branch
 - d. E – Equipment Branch
 - e. R – Legally Required
 - f. O – Optional Standby
- 3. Position Two – Voltage
 - a. G – 2400/4160 Volt
 - b. H – 480/277 Volt
 - c. J – 240/120 Volt
 - d. L – 208/120 Volt
- 4. Position Three – Distribution/Equipment
 - a. DP – Distribution Panel
 - b. PP - Power Panel
 - c. LP – Lighting Panel
 - d. ATS – Automatic Transfer Switch
 - e. BD – Bus Duct
 - f. MC – Motor Control Center
 - g. MS – Motor Starter
 - h. VFD – Variable Frequency Drive
- 5. Position Four - Building Level
 - a. SB2 – Sub-Sub-Basement
 - b. SB - Sub-Basement
 - c. 0 – Lower Level
 - d. 1 - First
 - e. 2 – Second
 - f. 3 - Third
- 6. Position Five - Sequential Panels/Equipment
 - a. -1 - First Panel
 - b. -2 - Second Panel
 - c. -3 - Third Panel

c. Electrical Testing

- 1. Independent testing agencies: Independent of manufacturers, suppliers and installers of components to be tested or inspected.
 - a. Testing Agency’s Field Supervisor for Power Component Testing: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing.
- 2. Contractor shall coordinate with testing agency and any additional requirements.

M) ELECTRICAL SYSTEMS

2. SYSTEM GUIDELINES

- a. **New Construction - Temporary Power and Building Service Considerations.**
 - 1. Summary: This section contains design criteria for Site Temporary power and Building Service requirements and options.
 - 2. New Construction – Site Temporary Power Requirements
 - a. 208/120V Trailer Power (lighting, receptacles, etc) and 480/277V Site Power (Equipment, Cranes, Elevators, etc) to be provided by ComEd.
 - b. Site Temporary power to be metered and billed to General Contractor.
 - c. ComEd Load letters, meters and engineering deposit shall be provided to ComEd by Electrical Contractor. Coordinate information with Project Electrical Engineer.
 - d. Site Construction Power shall NOT be supplied from University of Chicago buildings or existing switchgear.
 - 3. New Construction – Building Service
 - a. Primary Service to new buildings shall be minimum (2) 12.47kV Primary Utility Lines with Bus Tie and interlock system.
 - b. Service Transformers shall be owned by Local Utility (12.47kV) and are sized based on Load letters submitted to ComEd.
 - c. Secondary Voltage for new buildings shall be 480/277V, 3-phase, 4 wire and for plants 4160V, 3-phase, 3 wire.
 - 4. Building Service - Network Options
 - a. Primary Selective, Dual Source, Auto Transfer.
 - b. Secondary Selective, Dual Source, Auto Transfer.
 - c. Simple Radial, Dual Source, Manual Transfer.
 - 5. Building Service – Distribution Options
 - a. 4160 Volt distribution
 - b. 480/277 Volt distribution
 - c. 208/120 Volt distribution.

- 6. Building Service – Emergency Options
 - a. Code minimum plus all optional standby loads.
 - b. Code minimum plus predetermined kW of optional standby loads.
 - c. Code minimum only.
- 7. Building Service – Critical Equipment: In Buildings with Critical Equipment (Lab Instruction, Computer, Hot/Cold rooms, etc) a second 208/120V K-rated transformer and distribution panel shall be installed to “Isolate” critical loads.
- b. **Low-Voltage Electrical Power Conductors and Cables:**
 - 1. Summary: This section contains design criteria for building wire and cable, flexible cords, connecting devices and related material for wiring systems 600 Volts and below.
 - 2. Sustainability: General applicable items include regional manufacturers, recycled / American steel and copper and manufacturers use of low VOC coatings.
 - 3. Quality Assurance: Electrical components, devices and accessories shall be listed and labeled as defined in NFPA 70, Article 100, by Underwriters Laboratories and marked for intended use.
 - 4. Conductors:
 - a. All conductors shall be Copper. Aluminum is not acceptable.
 - b. Conductors #12 AWG and larger shall be stranded.
 - c. No conductors smaller than #12, except #14 for motor control, #16 stranded for annunciator wiring and #18 TFFN solid for fixture wiring (ballast to socket).
 - 5. Insulation Types
 - a. Service Entrance wiring in a raceway to be THHN-THWN, THWN-2.
 - b. Exposed Feeder wiring in a raceway to be THHN-THWN, THWN-2.
 - c. Concealed Feeder wiring in a raceway to be THHN-THWN, THWN-2.
 - d. Branch Circuit wiring in a raceway to be THHN-THWN, THWN-2.

- c. **Grounding and Bonding for Electrical Systems**
 - 1. Summary: This section contains design criteria for Electrical System Grounding and Bonding.
 - 2. Sustainability: there are not any specific sustainability requirements associated with this section.
 - 3. Design Intent: It is the intent of the University of Chicago to utilize a single grounding electrode system in all buildings. The incoming water main pipe, and a supplemental electrode in accordance with Article 250 of the Chicago Electrical Code shall be bonded to create the electrode system. Building steel shall be bonded to the system as well, where applicable. A separate equipment grounding conductor shall be included in all feeders and branch circuits. Conduit or raceway shall not be utilized for equipment grounding.
 - 4. Quality Assurance
 - a. Electrical components, devices and accessories shall be listed and labeled as defined in City of Chicago Electrical Code, Article 100, by Underwriters Laboratories and marked for intended use. Electrical components, devices and accessories must comply with UL 467.
 - b. Comply with City of Chicago Electrical Code for overhead –line construction and medium-voltage underground construction, comply with IEEE C2.
 - 5. Grounding Conductors: Ground Conductor for Wood Poles shall be #4 AWG minimum soft-drawn copper conductor. Conductor Protector for Wood Poles shall be half-round PVC or wood molding. If wood, use pressure-treated fir, cypress or cedar.

M) ELECTRICAL SYSTEMS

6. Equipment Grounding Conductors

- a. Comply with City of Chicago Electrical Code, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by City of Chicago Electrical Code are indicated.
- b. Busway Supply Circuits: Install insulated equipment grounding conductor from the grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
- c. Computer Outlet Circuits: Install insulated equipment grounding conductor in branch- circuit runs from computer-area power panels or power-distribution units.
- d. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.
- e. Air-Duct Equipment Circuits: Install an equipment grounding conductor to duct- mounted electrical devices operating at 120 V and more, including air cleaners and heaters. Bond conductor to each unit and to air duct.
- f. Water Heater, Heat-Tracing, and Anti-frost Heating Cables: Install a separate equipment grounding conductor to each electric water heater, heat-tracing, and anti-frost heating cable. Bond conductor to heater units, piping, connected equipment, and components.
- g. Bond al panelboard enclosures to its respective grounding bus. Bond all metal boxes to the grounding conductor.

7. Installation

- a. UFER Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG. If concrete foundation is less than 20 feet long, coil excess conductor within the base of the foundation. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to a grounding electrode external to concrete.

8. Overhead-Line Grounding

- a. Comply with IEEE C2 requirements. Use 2 or more parallel ground rods if a single ground rod electrode resistance to ground exceeds 25 ohms.
- b. Drive ground rods to a depth of 12 inches below finished grade in undisturbed earth.
- c. Ground Rod Connections: Use clamp-type connectors listed for the purpose for underground connections and connections to rods.
- d. Lightning Arresters: Separate arrester grounds from other grounding conductors.
- e. Secondary Neutral and Tank of Transformer: Interconnect and connect to grounding conductor.
- f. Protect grounding conductors running on surface of wood poles with molding extended from grade level up to and through communication service and transformer spaces.

9. Field Quality Control

- a. Owner will engage a qualified testing agency to perform field quality-control testing as required by specifications.

d. Raceway and Boxes for Electrical Systems

- 1. Summary: this section contains design criteria for raceways, fittings, boxes, enclosures and cabinets for electrical wiring.
- 2. Sustainability: There are not any specific sustainability requirements associated with this section.
- 3. Metal Conduit and Tubing
 - a. Rigid Steel Conduit shall comply with ANSI C80.1 standards.
 - b. Aluminum Rigid Conduit shall comply with ANSI C80.5 standards.
 - c. Intermediate Metal Conduit (IMC) shall comply with ANSI C80.6 standards.
 - d. Electrical Metal Tubing (EMT) shall comply with ANSI C80.3 standards. Fittings shall be Compression Type with insulated throat.
 - e. Flexible Metal Conduit (FMC) to be zinc coated steel.
 - f. Liquidtight Flexible Metal Conduit (LFMC) to be flexible steel conduit with PVC jacket.

- 4. Nonmetallic Conduit and Tubing: Rigid Nonmetallic Conduit (RNC) shall be NEMA TC 2, type EPC-40 PVC unless otherwise indicated.

5. Design and Performance Requirements

- a. Outdoors/Above Grade:
 - i. Exposed conduit shall be Rigid Aluminum.
 - ii. Concealed conduit shall be Rigid Aluminum.
 - iii. Boxes and Enclosures shall be NEMA 250, Type 3R or 4.
- b. Outdoors/Below Grade:
 - i. Beneath paved areas shall be Rigid Metal Conduit (RMC) with concrete encasement.
 - ii. Grouped or single runs shall be RNC for 3” trade size or smaller and RMC for trade size greater than 3”.
 - iii. Handholes and Pull Boxes shall be as follows Polymer concrete or Fiberglass- reinforced polyester resin based on individual application’s load rating requirements.
 - iv. Below Slab-on-Grade feeder conduits shall be concrete encased.
- c. Indoors:
 - i. RMC shall be used in exterior walls, slab penetrations, corrosive or hazardous locations and for exposed work at heights less than 8 feet.
 - ii. EMT, 2” maximum trade size, shall be used in interior partitions, above ceilings and for exposed work at heights eight feet above finished floor.
 - iii. RNC shall be used only for circuits below basement floors.
 - iv. Rigid steel conduit shall be used for damp or wet locations.
 - v. Boxes and Enclosures shall be NEMA 250, Type 1 or Type 4(damp or wet location).
- d. Minimum Raceway Size shall be 3/4-inch trade size. However, 1/2” trade size acceptable for flexible conduit in lengths not exceeding six feet and for hard conduit used for switch legs.
- e. Install raceway sealing fittings where required by City of Chicago Electrical Code.

M) ELECTRICAL SYSTEMS

- e. Identification for Electrical Systems
 - 1. Summary: This section contains design criteria for Electrical System Identification.
 - 2. Sustainability: There are not any specific sustainability requirements associated with this section.
 - 3. Design Intent: The intent of this section is to provide a means of identification that will help the University Operations and Maintenance personnel trouble shoot, repair, and maintain the electrical systems in each building. It is also the intent of the University to standardize the electrical identification for all electrical systems owned by the University.
 - 4. Submittals
 - a. Schedule of Nomenclature: Provide an index of electrical equipment and system components labeled during execution of contract scope of work.
 - b. Samples: For each type of label and sign to illustrate color, lettering style, and graphic features of identification products.
 - c. Name Plate Schedule: Prior to making name plates, submit a complete schedule to the University for approval indicating name plate size, lettering style, size, color, and actual name plate information.
 - 5. Installation
 - a. Circuits with More Than 600 V: Identify raceway and cable with “DANGER--HIGH VOLTAGE” labels in black letters 2 inches high, at 10-foot intervals over a continuous orange background. Identify the following:
 - i. Entire floor area directly above conduits running beneath and within 12 inches of a basement or ground floor that is in contact with earth or is framed above unexcavated space.
 - ii. Wall surfaces directly external to conduits concealed within wall.
 - iii. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in the building, or concealed above suspended ceilings.
 - iv. Entire surface of exposed conduits.

- b. Raceway and Cable Labels
 - i. Adhesive Labels: Preprinted, flexible, self-adhesive vinyl with legend over- laminated with a clear, weather- and chemical-resistant coating.
 - ii. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
- c. Circuit Identification Labels on Boxes
 - i. Exposed Boxes: Indicate panel name and circuit number with black indelible marker.
 - ii. Concealed Boxes: Indicate panel name and circuit number with black indelible marker.
- d. Color-Coding of Secondary Phase Conductors: Use the following colors for service, feeder and branch-circuit phase conductors:
 - i. 208/120V Conductors
 - Phase A: Black
 - Phase B: Red
 - Phase C: Blue
 - Grounded Conductor: White
 - Grounding Conductor: Green
 - ii. 480/277V Conductors
 - Phase A: Yellow
 - Phase B: Brown
 - Phase C: Orange
 - Grounded Conductor: Gray
 - Grounding Conductor: Green with Yellow Stripe
- e. Power receptacles and light switches shall have the associated circuit number and panelboard identified with black indelible marker on the interior of the cover plate.
- f. Conduits connected to Distribution or Branch Panels: Indicate on Raceway with black indelible marker the panel name and circuit number of the enclosed conductors.

M) ELECTRICAL SYSTEMS

6. Equipment Identification Nameplates

a. Indoor (By Manufacturer/Factory Installed)

i. Engraved, Three-layer, Laminated Acrylic or Melamine Nameplate: Stainless steel screws mount nameplate to equipment. White letters on a black background, except emergency power equipment nameplates are to have white letters on a red background. Minimum letter height shall be 3/8” unless noted otherwise.

b. Outdoor (By Manufacturer/Factory Installed)

i. Engraved, Three-layer, Laminated UV Resistant Acrylic or Melamine Nameplate: Attached with non-corrosive mechanical fastener or other permanent method to maintain compliance with NEMA rating of enclosure. White letters on a black background, except emergency power equipment nameplates are to have white letters on a red background. Minimum letter height shall be 1/2” unless noted otherwise.

c. Equipment Identification Nameplates (In Field): On each unit of equipment, install unique designation nameplate that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply nameplates to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

i. Nameplate Instructions:

1. Indoor Equipment: Engraved, laminated acrylic self-adhesive backed. Unless otherwise indicated, provide a single line of text with 3/8” high letters on 1-1/2” high nameplate; where 2 lines of text are required, use nameplates sized 2” high.

2. Outdoor Equipment: Engraved, laminated UV resistant acrylic nameplates with 1/2” high letters. Outdoor equipment labels are to be factory applied with non- corrosive mechanical fasteners or other permanent method to maintain compliance with NEMA rating of enclosure.

3. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor. Install nameplates for equipment including, but not limited to, the following:

1. Panelboards, electrical cabinets, and enclosures

2. Access doors and panels for concealed electrical items

3. Electrical switchgear and switchboards, including each device

4. Transformers

5. Electrical substations

6. Emergency system boxes and enclosures

7. Motor-control centers, including each device

8. Disconnect switches

9. Enclosed circuit breakers

10.Motor controllers

11. Pushbutton stations

12. Automatic Transfer Switches

13. Contactors

14. Remote-controlled switches, dimmer modules, and control devices

15. Battery inverter units

16. Battery racks

17. Power-generating units

18. Voice and data cable terminal equipment

19. Master clock and program equipment

20. Intercommunication and call system master and staff stations

21. Television/audio components, racks, and controls

22. Fire alarm control panel and annunciators

23. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks

24. Monitoring and control equipment

25. Uninterruptible power supply equipment

26. Terminals, racks, and patch panels for voice and data communication and for signal and control functions

27. Non-concealed junction box covers of auxiliary electrical systems

d. Nameplates shall indicate:

i. Unique Name

ii. Electrical Source

iii. Location of Source

iv. Voltage

v. Amperage Rating

vi. Equipment Being Served

vii. Location of Equipment Being Served
- The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.
- THE UNIVERSITY OF CHICAGO FACILITIES SERVICES
- FS² Volume III - Design Requirements | Page 199

M) ELECTRICAL SYSTEMS**f. Overcurrent Protective Device Coordination**

1. Summary: This section contains design criteria for Fault Current Studies, Protective Device Evaluation Studies, Protective Device Coordination Studies, Arc-Flash Hazard Analysis and Shock Hazard Analysis for the electrical distribution system from all power sources rated 50 volts or greater.
2. Sustainability: There are not any specific sustainability requirements associated with this section.
3. Quality Assurance
 - a. Studies shall use AutoCad 14 or higher and Version 3.8 Revision 1.6 of SKM Power Tools for Windows.
 - b. Software other than that indicated above may be recommended by the engineer to the University for consideration.
 - c. Studies shall be overseen by a Professional Engineer licensed in the State of Illinois.
4. Arc Flash Hazard Analysis: Provide a complete Arc Flash Hazard Analysis for the project indicated in the accompanying Request for Proposal (RFP).
 - a. When indicated by the RFP, the Arc Flash Hazard Analysis shall be performed independent of a construction project. The AFC is expected to survey the building, collect appropriate data and prepare reports as described in the RFP. Recommendations to reduce incident energy levels shall be included in the draft report for review by the University. Recommendations that are immediately implemented shall be reflected in the final report; outstanding recommendations will be addressed in future capital projects and the study updated at that time.

- b. When indicated by the RFP, the Arc Flash Hazard Analysis shall be performed in concert with the A/E of record during the design and construction phases of the project. The AFC is expected to coordinate and correspond regularly with the A/E as required to review the electrical design as it progresses and provide input to the design to provide the lowest incident energy levels practical. This collaborative process is expected to occur throughout the entire design and construction phase of the project.
- c. When indicated by the RFP, the Arc Flash Hazard Analysis shall be performed by the A/E of record as an integral part of the design and construction phases of the project. The AFC is expected to review the electrical design as it progresses and ensure that arc flash hazards are reduced by design. The resulting electrical design shall have the lowest incident energy levels practical.

5. Applicable Codes and Standards

- a. ANSI Z535.4 (American National Standard for Product Safety Signs and Labels)
- b. CSA Z462 – Workplace Electrical Safety Standard
- c. IEEE-1584 – Latest Edition (Institute of Electrical & Electronic Engineers Guide for Performing Arc-Flash Calculations)
- d. IEEE-141 – Latest Edition (Institute of Electrical & Electronic Engineers Recommended Practice for Industrial Plants (IEEE Red Book))
- e. IEEE-241 – Latest Edition (Institute of Electrical & Electronic Engineers Recommended Practice for Electric Power Systems in Commercial Buildings (IEEE Gray Book))
- f. IEEE-242 – Latest Edition (Institute of Electrical & Electronic Engineers Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems – Buff Book)
- g. IEEE-399 – Latest Edition (Institute of Electrical & Electronic Engineers Recommended Practice for Power System Analysis – Brown Book)

6. Quality Assurance

- a. Studies shall be prepared using Power Tools software obtained from SKM Systems Analysis, Inc.
- b. Studies shall be signed and sealed by a Professional Engineer registered in the State of Illinois. All elements of the study shall be performed under the direct supervision and control of the Professional Engineer.
- c. Studies shall be prepared per current applicable codes and standards.
- d. Studies shall be based on systems designed and specified as “fully-rated” systems. “Series-rated” systems are not acceptable.

7. Safety and Security

- a. The AFC shall comply with all applicable OSHA regulations as well as the most current edition of NFPA-70E when doing on-site field investigation and data gathering. Determination of appropriate PPE during data gathering shall be the responsibility of the AFC.
- b. A minimum of two qualified persons as defined by NFPA-70E with appropriate PPE shall be on-site when field survey work of energized equipment is underway. The qualified personnel shall be employees of the AFC or employees of a University approved sub-contractor.
- c. All access to the project work site shall be coordinated through the University. The AFC shall submit a proposed schedule for site visits to the Arc Flash Coordinator. The proposed schedule shall identify the building requiring access, room numbers, proposed day and duration. The proposed schedule shall be submitted in writing two weeks prior to the proposed visit.
- d. There are not planned power outages for the purpose of conducting the Arc Flash Hazard Assessment. The AFC must submit a written request to the University’s Arc Flash Coordinator assigned to the project if an outage is needed.

M) ELECTRICAL SYSTEMS

8. On-Site Data Gathering and Reporting

- a. The following data shall be gathered and summarized:
 - i. Locations (Room Numbers) of all equipment that will require Arc Flash Hazard labels. Note that this data is necessary to complete the labels and must be manually added to the MS Excel spreadsheet prior to importing into the label maker software.
 - ii. Fuses – manufacturer, type, Amp rating, Short circuit rating, etc.
 - iii. Circuit Breakers – manufacturer, type, Amp rating, Short circuit rating, settings, etc.
 - iv. Panels and Switchboards – manufacturer, type, Voltage rating, Amp rating, Short Circuit Rating, Ratings of circuit breakers / fuses, etc.
 - v. Primary Transformers – manufacturer, rating, impedance, fusing, short circuit available, etc.
 - vi. Secondary Transformers – manufacturer, type, Voltage rating, Amp rating, impedance, fusing, etc.
 - vii. Wire / Cable – size, insulation type, conductor type, length, etc.
 - viii. SCR and/or Isolation Transformers – size, impedance, fusing, etc.
 - ix. Disconnects / Combination Motor Starters – manufacturer, type, Voltage rating, Amp rating, Short Circuit Rating, OCPD Rating, etc.
 - x. Bus Duct – manufacturer, Voltage rating, Amp rating, conductor type, short circuit rating, impedance value (based upon model number), etc. (Obtain the following information regarding all Buckets and Disconnects on the duct – Amp rating, OCPD Rating, length, etc.)
 - xi. Equipment Panels – All end use equipment that is permanently connected to the building electrical system. Document all short circuit ratings, fusing / circuit breakers, etc.

- xii. Motors and other equipment that will contribute to the available short circuit current. Collect motor data for all motors 50 Hp and above.
- xiii. VFD- manufacturer, Voltage rating, Amp rating, bypass, OCPD Rating, etc.
- xiv. Engine-Generator – manufacturer, type, Voltage rating, Amp rating, KVA rating, KW rating, impedance, etc.
- xv. Automatic Transfer Switch – manufacturer, Voltage rating, Amp rating.

b. Infrared Scan Requirements:

- i. At the time data is being gathered from existing equipment for the Arc Flash Hazard Analysis the AFC shall also utilize an Infrared Camera to scan the equipment being surveyed.
- ii. The Infrared Scan equipment shall be a Fluke TIR series or equal capable of recording a digital image.
- iii. The scope of the IR Scan is to identify items that require further investigation and preventive maintenance.
- iv. The use of current measurement devices is not anticipated or required.
- v. Calculations or detailed engineering analysis of IR images is not anticipated or required.
- vi. The scope of the Infrared Scan is to scan the equipment for connection issues.
- vii. Data gathering for the Arc Flash Hazard Analysis presents an opportunity to perform a basic Infrared Scan of the equipment being surveyed. It is not the intent of this project that the Infrared Scan be a complete and detailed IR analysis. Its purpose is to identify items of concern for further evaluation by the University.

9. System Short Circuit Analysis

- a. Calculate the maximum available short circuit current in amperes rms symmetrical at each point of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three- phase bolted short circuit.
- b. Study electrical distribution system scenarios that result in maximum and minimum fault current. These scenarios shall include at a minimum the following:
 - i. Normal configuration.
 - ii. Emergency power system operation.
 - iii. Alternate sources when multiple sources and configurations are available.
 - iv. Feeder cable length variation from modeled value +/- 10%.
- c. Scenarios evaluated shall also make use where available of the maximum and minimum fault current values available from Local Utilities.

M) ELECTRICAL SYSTEMS

10. Equipment Evaluation Analysis:
- a. Confirm that interrupting ratings are equal to or higher than calculated ½ cycle symmetrical fault current for 600 Volt over current protective devices.
 - b. Interrupting Rating Analysis
 - i. Calculate momentary and interrupting duties on the basis of maximum available fault current.
 - ii. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 141, IEEE 241 and IEEE 242.
 - 1. Transformers:
 - a. ANSI C57.12.10
 - b. ANSI C57.12.22
 - c. ANSI C57.12.40.
 - d. IEEE C57.12.00.
 - e. IEEE C57.96
 - 2. Medium Voltage Circuit Breakers: IEEE C37.010
 - 3. Low Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.01
 - 4. Low Voltage Fuses: IEEE C37.46.
 - c. Apply multiplication factors listed in the standards to ½ cycle symmetrical fault current for devices and equipment rated for asymmetrical fault current.
 - d. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground fault currents. Ensure that short circuit withstand ratings are equal to or higher than calculated ½ cycle symmetrical fault current.

11. Shock Hazard Analysis: Perform a Shock Hazard Analysis in accordance with NFPA 70E. The completed study shall determine:
- a. Voltage exposure at each location.
 - b. Shock Protection Boundaries.
 - i. Limited Approach.
 - ii. Restricted Approach.
 - c. Required PPE for shock hazard protection.

M) ELECTRICAL SYSTEMS

12. Overcurrent Protective Device Coordination Analysis:
- a. Protective Device Coordination Study for all system devices (adjustable and fixed).
 - b. Provide TCC curves for each type of breaker down to and including the 20A and 30A breakers in branch circuit panelboards.
 - c. The coordination study shall include TCC curves for all devices on the emergency system and verify proper coordination thereof per NEC.
 - d. Perform coordination study in compliance with IEEE 399.
 - e. Calculate the maximum and minimum ½ cycle short circuit currents.
 - f. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short circuit currents.
 - g. Calculate the maximum and minimum ground fault currents.
 - h. Comply with IEEE recommendations for fault currents and time intervals.
 - i. Transformer Primary Overcurrent Protective Devices:
 - i. Devices shall not operate in response to the following:
 - 1. Inrush current when first energized.
 - 2. Self cooled, full-load current or forced air cooled, full-load current, whichever is specified for that transformer.
 - 3. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
 - ii. Devices settings shall protect transformers according to IEEE C57.12.00, for fault currents.
 - j. Motors served by voltages more than 600 volts shall be protected according to IEEE 620.
- k. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturer or from listed standards indicating conductor size and short-circuit current.
- l. Tabular Format of Settings Selected for Overcurrent Protective Devices:
- i. Device Tag
 - ii. Relay-current transformer ratios; and tap, time-dial, and instantaneous- pickup values.
 - iii. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
 - iv. Fuse-current rating and type.
 - v. Ground-fault relay-pickup and time-delay settings.
- m. Coordination Curves:
- i. Prepare to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate set of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
 - 1. Device Tag
 - 2. Voltage and current ratio for curves
 - 3. Three-phase and single phase damage points for each transformer.
 - 4. No damage, melting, and clearing curves for fuses.
 - 5. Cable damage curves.
 - 6. Transformer inrush points.
 - 7. Maximum fault current cutoff point.
 - 8. Single-line diagram inset on the Time Current Curves
- ii. Organize labeling on the Time Current Curves so that the labels appear on the left side and go from top to bottom to match the order of devices from left to right. Single line diagram shall be located in the upper right corner whenever possible.
 - iii. Format report so that Time Current Curves always appear on the right side of the binder and the corresponding breaker settings appear on the left side of the binder. This is to facilitate viewing of settings and curves at the same time.
 - iv. Report shall contain hardcopy and softcopy of:
 - 1. Coordination study input data, including completed computer program input data sheets.
 - 2. Coordination curves for each major electrical equipment / circuit breaker / fuse / cable, etc.
 - 3. Data sheets for setting of overcurrent protective devices.
- n. Overcurrent Protection Devices and Fuse Recommendations: (Construction Related Projects)
- i. The AFC shall make recommendations during the design phase of the project to the A/E in regard to the specification of overcurrent protective devices and fuse ratings that provide for the lowest incident energy levels and greatest degree of coordination. The A/E shall include this information as "basis of design" on the contract documents. The AFC shall strive to avoid selection of proprietary equipment and devices and shall advise the University when such devices are necessary or warranted to achieve incident energy goals.
 - ii. The AFC shall review and make recommendations during the construction phase of the project to the A/E in regard to the submitted overcurrent protective devices and fuse ratings to ensure the submitted equipment complies with the incident energy levels established during the design phase.

M) ELECTRICAL SYSTEMS

- 13.Arc Flash Hazard Analysis

a. Arc Flash Study Limits

i. These study requirements exceed the requirements of the NFPA-70E standards and shall include all electrical equipment on the buildings power distribution system as described below:

1. Buildings served by a public utility shall be studied from the primary side of the service entrance transformer using fault current and X/R ratio values that the AFC obtains from the public utility.

2. All electrical panel boards and load centers including single phase panel boards and load centers. (Computer model single phase devices as three phase devices.)

3. All electrical equipment disconnect switches.

4. All bus ducts.

5. All open transformers.

6. All Variable Frequency Drives (VFD)

7. DC systems where applicable.

8. UPS Systems where applicable

9. All disconnect switches that are integral to equipment that is hardwired to the building electrical system. (HVAC equipment, Kitchen equipment, etc.)

ii. The intent is that all electrical equipment subject to access while energized or that is a point of a Lock out / Tag out operation is labeled. Notable exclusions from the study include 20 Amp lighting branch circuits, receptacle branch circuits and enclosed transformers.

iii. The study requirements shall include all electrical distribution system components that are served by power source rated 50 Volts or greater.

b. Arc Flash Hazard Analysis:

i. Analysis methods shall conform to NFPA 70E and IEEE 1584.

ii. Analysis shall include all voltage classes of equipment from the service entrance down to 50 volts.

iii. Analysis shall calculate and assign Arc Flash values based upon worst case operational configuration. Summaries shall indicate both conditions. Applied labels shall reflect the highest IE value. Examples include:

1. UPS’s shall be assumed to be in bypass mode.

2. VFD’s shall be assumed to be in bypass mode.

3. ATS’s sand MTS’s hall be assumed to be on standby power.

iv. Calculate the Arc Flash Incident Energy (IE) for each point in the system(s). This includes values for the line side of each main overcurrent device in panel boards, switchboards, MCCs.

v. Calculate the Arc Flash Boundary distances for each point in the system(s). This includes values for the line side of each main overcurrent device in panel boards, switchboards, MCCs.

vi. Prepare recommendations based upon modeling OCPD device settings and ratings to lower IE to a hazard category of “1” when possible but no higher than “2”. (Temporary maintenance settings can be used to accomplish this, if necessary with the University’s approval.)

vii. Report shall contain hardcopy and softcopy of the Arc Flash Evaluation showing the bus name, protective device name, bus (kV), bus bolted fault (kA), protective device arcing fault (kA), trip / delay time (sec.), arc type, arc flash boundary (in.), working distance (in.), incident energy (cal/cm2), and required protective FR clothing class.
- viii. The completed study shall include:

1. Device Tag for each point assessed

2. Voltage exposure at each location

3. Available bolted fault current

4. Hazard Risk Category

5. Arc-Flash Protection Boundary

6. Working Distance

7. Incident Energy (in cal/cm2)

8. Required PPE

9. Components or equipment that have insufficient AIC for available fault current, or are over-dutied

10. Assessment date

11. Recommendation regarding results and how to lower hazards

12. Data Tables: Report shall contain hardcopy and softcopy of Arc Flash Hazard Assessment data tables from SKM software.

14. Deliverables: Refer to Electrical Overcurrent Studies document as part of these standards for specific requirements on reports concerning electrical overcurrent protection.

VOLUME III – DESIGN REQUIREMENTS

M) ELECTRICAL SYSTEMS

15. Arc Flash Warning Labels

- a. The contractor of the Arc Flash Hazard Analysis shall provide a 4 in. x 6 in. thermal transfer type label of high adhesion polyester for each work location analyzed.
- b. All labels will be based on recommended overcurrent device settings and will be provided after the results of the analysis have been presented to the owner and after any system changes, upgrades or modifications have been incorporated in the system.
- c. The label shall include the following information, at a minimum:
 - i. Location designation
 - ii. Nominal voltage
 - iii. Flash protection boundary
 - iv. Hazard risk category
 - v. Incident energy or energy range corresponding to reported Hazard risk category.
 - vi. Working distance
 - vii. Engineering report number, revision number and issue date.
- d. Labels shall be machine printed, with no field markings.
- e. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.
 - i. For each 600, 480 and applicable 208 volt panelboard, one arc flash label shall be provided.
 - ii. For each motor control center, one arc flash label shall be provided.
 - iii. For each low voltage switchboard, one arc flash label shall be provided.
 - iv. For each switchgear, one flash label shall be provided.
 - v. For medium voltage switches one arc flash label shall be provided
 - vi. For each machine control panel, one arc flash label shall be provided.
 - vii. For each bus duct plug, one arc flash label shall be provided.

- f. Labels shall be field installed by the contractor performing the engineering analysis.

16. Arc Flash Training

- a. Training is optional. Contractor is to verify with the owner if training is required.

M) ELECTRICAL SYSTEMS

- g. **Electrical Power Monitoring and Control**
 - 1. Summary: This section contains design criteria for Electrical Power System Monitoring and Control.
 - 2. Sustainability: There are not any specific sustainability requirements associated with this section.
 - 3. Design and Performance Requirements
 - a. Power monitoring and control shall be provided for Substations, service entrances and as specifically directed by the University.
 - b. Refer to BAS Facility Standards section for networking and communications protocol requirements.
 - c. Power Monitors shall monitor the following RMS Real-Time values:
 - i. Current: Phases, Neutral, Average of three phases, unbalance percentage
 - ii. Voltage: Line-to-Line each phase, Line-to-Line average of phases, Line-to-Neutral percent unbalance.
 - iii. Power: Per phase and three phase total.
 - iv. Reactive Power: Per phase and three phase total.
 - v. Apparent Power: Per phase and three phase total.
 - vi. Power Factor: Per phase and three phase total.
 - vii. Displacement Power Factor: Per phase and three phase total.
 - viii. Frequency.
 - ix. Total Harmonic Distortion (THD): Current and Voltage.
 - x. Accumulated, Incremental and Conditional Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
 - d. Power Monitors shall monitor and perform the following calculations:
 - i. Demand Current calculations, per Phase, Three phase average and neutral: Present, Running average, Last completed interval, Peak.
 - ii. Demand Real Power calculations, Three phase total: Present, Running average, Last completed interval, Predicted, Peak, coincident with peak kVA demand, coincident with kVAR demand.
 - iii. Demand Reactive Power calculations, Three phase total: Present, Running average, Last completed interval, Predicted, Peak, coincident with peak kVA demand, coincident with kVAR demand.
 - iv. Demand Apparent Power calculations, Three phase total: Present, Running average, Last completed interval, Predicted, Peak, coincident with peak kVA demand, coincident with kVAR demand.
 - v. Average Power Factor calculations, Demand Coincident, Three phase total: Last completed interval, Coincident with kW peak, Coincident with peak kVA demand, Coincident with kVAR demand. Power Analysis Values:
 - 1. THD - Voltage and Current, per phase, three phase neutral
 - 2. Displacement Power Factor – per phase, three phase
 - 3. Fundamental Voltage – Magnitude and angle per phase
 - 4. Fundamental Currents – Magnitude and angle per phase
 - 5. Fundamental Real Power – per phase, three phase
 - 6. Fundamental Reactive Power – per phase
 - 7. Harmonic Power – per phase, three phase
 - 8. Phase Rotation; Unbalance – Current and Voltage
 - 9. Harmonic Magnitudes and Angles for Current and Voltages – per phase, up to 31st harmonic.
 - 4. Manufacturers
 - a. ABB Power T & D Company Inc.; Distribution Systems Division
 - b. Cutler-Hammer Product; Eaton Corporation
 - c. GE Electrical Distribution and Control
 - d. Siemens Energy & Automation, Inc.
 - e. Square D Co.; Power Management Organization. (ION Meters are University Standard)

M) ELECTRICAL SYSTEMS

h. Lighting Control Devices

- 1. Summary: This section contains design criteria for time switches, outdoor and indoor photoelectric switches, switch box occupancy sensor, indoor occupancy sensors, outdoor motion sensors and multi-pole contactors.
- 2. Sustainability: Applicable items include regional manufacturers, occupancy sensors and day lighting sensors.
- 3. Design and Performance Requirements
 - a. Occupancy sensors located in restrooms to be moisture resistant and dual technology.
 - b. Refer to BAS standards for additional information.
- 4. Manufacturers
 - a. Time Switches
 - i. Area Lighting Research, Inc.
 - ii. Intermatic, Inc.
 - iii. Paragon Electric Co.
 - iv. Leviton Mfg. Company Inc.
 - v. WattStopper
 - b. Outdoor Photoelectric Switches
 - i. Area Lighting Research, Inc.
 - ii. Leviton Mfg. Company Inc.
 - iii. Intermatic, Inc.
 - iv. Paragon Electric Co.
 - c. Indoor Photoelectric Switches
 - i. Area Lighting Research, Inc.
 - ii. Leviton Mfg. Company Inc.
 - iii. Novitas, Inc.
 - iv. Paragon Electric Co.
 - v. WattStopper
 - d. Indoor Occupancy Sensors
 - i. Hubbell
 - ii. Leviton Mfg. Company Inc.
 - iii. Sensor Switch, Inc.
 - iv. WattStopper
 - e. Outdoor Occupancy Sensors
 - i. Paragon Electric Co.
 - ii. RAB Electric Manufacturing Inc.
 - iii. Leviton Mfg. Company Inc.

f. Lighting Contactors

- i. Allen-Bradley/Rockwell Automation
- ii. ASCO Power Technologies, LP; a division of Emerson Electric Co.
- iii. Eaton Electrical Inc.; Cutler-Hammer Products
- iv. GE Industrial Systems; Total Lighting Control
- v. Square D; Schneider Electric

i. Low-Voltage Transformers

- 1. Summary: This section contains design criteria for low-voltage, dry-type transformers rated 600V and less, with capacities up to 1000 KVA.
- 2. Sustainability: General applicable items include regional manufacturers, recycled / American steel and copper and manufacturers use of low VOC coatings.
- 3. Quality Assurance
 - a. Transformers shall be UL listed and comply with IEEE C57.12.91
 - b. Energy efficient transformers rated 15 KVA and larger to be certified as meeting NEMA TP-1, Class 1 efficiency levels when tested according to NEMA TP-2.
- 4. Design and Performance Requirements
 - a. Isolate core and coil from enclosure with suitable vibration absorbing mounts.
 - b. All transformers must be delta-wye configuration.
 - c. Transformer impedance levels must be minimum of three percent to limit short-circuit currents on secondary systems.
 - d. All transformers rated up to 225 KVA must be air cooled.
 - e. All transformers must have copper windings. Aluminum windings are not acceptable.
 - f. All transformers shall have insulation class of 220 deg C with a maximum of 80 deg C rise under full load above 40 deg C ambient temperature.
 - g. K-Rated transformers shall be used when serving loads with a high degree of harmonics.
 - h. Transformer 15 kVA or smaller shall have (2) 5% FCBN (full capacity below normal) primary taps and transformers larger than 15 kVA shall have (2) 2.5% FCAN (full capacity above normal) and (4) 2.5% FCBN primary taps.

5. Enclosures

- a. Indoor: Ventilated, NEMA 250, Type 2
- b. Outdoor: Ventilated, rain-tight, NEMA 250, Type 3R
- c. Other Wet or Damp Indoor: Ventilated, drip-proof, NEMA 250, Type 2
- d. Finish color shall be ANSI 61 gray.

6. Manufacturers

- a. Eaton Corporation; Cutler-Hammer Products
- b. GE Electrical Distribution & Control
- c. Jefferson Electric, Inc.
- d. Siemens Energy & Automation, Inc.
- e. Sola/Hevi-Duty Electric
- f. Square D; Schneider Electric

7. Installation

- a. Transformers shall be floor mounted atop concrete bases of at least 4 inches larger than the foot print of the unit and 4 inches high.
- b. Suspended transformers are not acceptable.
- c. Mount transformers on neoprene pads.

8. Quality Control: Prior to energizing transformer, perform moisture insulation resistance tests.

M) ELECTRICAL SYSTEMS

- j. Switchgear
 - 1. Summary: This section contains design criteria for metal-enclosed, low-voltage, power circuit- breaker switchgear rated 1000 Volts and less.
 - 2. Sustainability: General applicable items include regional manufacturers, recycled / American steel and copper and manufacturers use of low VOC coatings.
 - 3. Design and Performance Requirements
 - a. Switchgear shall be located in electrical equipment rooms or other equipment rooms designed for such. Access to rooms shall be accessible to qualified personnel only.
 - b. Phase, Neutral and Ground Buses shall be hard-drawn copper 98% conductivity and silver plated. (Aluminum is not acceptable.)
 - c. Switchgear shall be mounted atop concrete bases of no more than 2 inches larger than the foot print of the unit and 4 inches high.
 - d. Draw-out circuit breakers shall be equipped with interlocks to prevent movement of circuit breaker when closed and to prevent closure when in test, connected or disconnected position.
 - e. Switchgear shall have utility metering in a separate utility metering compartment that complies with the utility company requirements.
 - 4. Enclosures
 - a. Indoor Locations: NEMA 250, Type 1
 - b. Outdoor Locations: NEMA 250, Type 3R Walk-in, Non Walk-in
 - b. Switchgear enclosure shall be made of steel and painted with manufacturer’s standard gray finish over a rust inhibiting primer on phosphatizing treated metal surfaces.
 - c. Circuit breaker compartments shall be equipped to house draw-out type circuit breakers and fitted with hinged outer doors.
 - d. Enclosures to be fabricated with removable, hinged, rear cover panels secured by captive thumbscrews to allow access to rear interior of switchgear.

- 5. Quality Assurance
 - a. Electrical components, devices and accessories shall be listed and labeled by a testing agency acceptable to the Authority Having Jurisdiction and marked for intended use.
 - b. Warranty shall be manufacturer’s standard or 12 months; whichever is greater.
 - c. Obtain switchgear through on source from a single manufacturer.
- 6. Project Conditions
 - a. Provide minimum seven (7) days notice to Owner’s Designated Representative of a proposed interruption of electrical service.
- 7. Manufacturers:
 - a. Eaton Corporation; Cutler-Hammer Products
 - b. General Electric Co.; Electrical Distribution & Protection Division
 - c. Siemens Energy & Automation, Inc.
 - d. Square D; Schneider Electric
- 8. Identification: Refer to Switchgear naming convention in Common Work Results for Electrical Design Standards.
- 9. Provide working space per City of Chicago Code.

M) ELECTRICAL SYSTEMS

k. Switchboards

1. Summary: This section contains design criteria for service and distribution switchboards rated 600V and less.

2. Sustainability: General applicable items include regional manufacturers, recycled / American steel and copper and manufacturers use of low VOC coatings.

3. Design and Performance Requirements

a. Each switchboard shall have its own main disconnecting means. Typically this will be a main breaker, molded case switch or fusible switch.

b. Each switchboard shall have fixed individually mounted main device, panel-mounted branches and sections rear aligned.

c. Switchboards shall have Transient Voltage Surge Suppressor (TVSS) device per TVSS device Facility standards.

d. Switchboards shall be located in electrical equipment rooms or other equipment rooms designed for such. Access to rooms shall be accessible to qualified personnel only.

4. Quality Assurance

a. Electrical components, devices and accessories shall be listed and labeled by a testing agency acceptable to the AHJ and marked for intended use.

b. Warranty shall be manufacturer’s standard or 12 months; whichever is greater.

5. Project Conditions: Provide minimum seven (7) days notice to Owner’s Designated Representative of a proposed interruption of electrical service.

6. Enclosures

a. Switchboards to be Front-connected, Front-accessible with sections front and rear aligned.

b. Rated for environmental conditions as follows:

i. Indoor Locations: NEMA 250, Type 1

ii. Outdoor Locations: NEMA 250, Type 3R

7. Manufacturers

a. Eaton Corporation; Cutler-Hammer Products.

b. General Electric Co, Electrical Distribution & Protection Div.

c. Siemens Energy & Automation, Inc.

d. Square D: Schneider Electric

8. Manufacturers for projects requiring custom built switchboards.

a. Peterson Electric Panel Mfg. Co.

b. Chicago Switchboard

c. Illinois Switchboard Corporation

d. Switchboard Apparatus Inc.

9. Construction

a. All bus bars to be tin or silver plated hard-drawn copper of 98 percent conductivity.

b. All bus bars shall be rated for maximum short circuit protection.

c. Horizontal bus shall be fully rated. No tapered bus allowed.

10. Installation: Floor mounted switchboards shall be mounted atop concrete bases of at least 4 inches larger than the foot print of the unit and 4 inches high.

11. Identification: Refer to naming convention in Common Work Results for Electrical Design Standards.

12. Provide working space per City of Chicago Code.
- The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.
- THE UNIVERSITY OF CHICAGO FACILITIES SERVICES
- FS² Volume III - Design Requirements | Page 209

M) ELECTRICAL SYSTEMS

1. Panelboards

1. Summary: This section contains design criteria for panelboards and distribution panels.

2. Sustainability: General applicable items include regional manufacturers, recycled / American steel and copper and manufacturers use of low VOC coatings.

3. Design and Performance Requirements

a. Each panelboard shall have its own main disconnecting means. (Main breaker or molded case switch.)

b. Panelboards shall be located in electrical equipment rooms or other equipment rooms designed for such. Access to rooms shall be accessible to qualified personnel only. Panelboards shall not be located in corridors or other areas accessible to the public.

c. Load center construction is not acceptable.

d. Modular or integrated panel board assemblies are not acceptable.

e. Panelboards installed flush in masonry or framed walls shall have a minimum of four 1” empty conduits stubbed into accessible ceiling space, raised floor space or below slab (if not slab on grade).

4. Quality Assurance

a. Electrical components, devices and accessories shall be listed and labeled by a testing agency acceptable to the Authority Having Jurisdiction and marked for intended use.

b. Warranty shall be manufacturer’s standard or 12 months; whichever is greater.

5. Project Conditions: Provide minimum seven (7) days notice to Owner’s Designated Representative of a proposed interruption of electrical service.

6. Enclosures; Rated for environmental conditions as follows:

a. Indoor Locations: NEMA 250, Type 1

b. Outdoor Locations: NEMA 250, Type 3R

c. Kitchen and Lab Areas: NEMA 250, Type 4X, StainlessSteel.

d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4

e. Hazardous Areas Indicated on Plans: NEMA 250, Type 7C
7. Branch Circuit Panelboards (225 Amps and under):

a. Manufacturers shall be limited to the following:

i. Panelboards, Overcurrent Protective Devices, Controllers, Contactors and Accessories:

· Eaton Corporation; Cutler-Hammer Products

· General Electric Co.; Electrical Distribution & Protection Division

· Siemens Energy & Automation, Inc.

· Square D; Schneider Electric

ii. Manufacturers for projects requiring custom built panelboards.

· Peterson Electric Panel Mfg. Co.

· Chicago Switchboard.

· Illinois Switchboard Corporation.

· Switchboard Apparatus Inc.

b. Minimum enclosure width of 20” or as approved for renovations.

c. All circuit breakers shall be bolt on type.

d. All circuit breakers shall be fully rated for available interrupting current. (Series rated is not acceptable.)

e. Phase, Neutral and Ground Buses shall be hard-drawn copper 98% conductivity. (Aluminum is not acceptable.)

f. Breakers shall indicate tripped condition by a means other than the off position.

g. Hinged-to-box (tub), front door construction.

h. Panelboards with 30 or more branch circuits shall have a minimum of two door latches for each door.

i. Panelboards shall be equipped with 20% spare breakers. A/E shall note that it is not the intention of this guideline to provide an extra panelboard just to meet this requirement.

j. Panelboards shall be fully bussed with mounting brackets for all positions including spaces.
8. Power Panelboards (1,200 Amps and under to 225 Amps)

a. Manufacturers shall be limited to the following:

i. Panelboards, Overcurrent Protective Devices, Controllers, Contactors and Accessories:

· Eaton Corporation; Cutler-Hammer Products

· General Electric Co.; Electrical Distribution & Protection Division

· Siemens Energy & Automation, Inc.

· Square D; Schneider Electric

ii. Manufacturers for projects requiring custom built panelboards.

· Peterson Electric Panel Mfg. Co.

· Chicago Switchboard

· Illinois Switchboard Corporation

· Switchboard Apparatus Inc.

b. All circuit breakers shall be bolt on type.

c. All circuit breakers shall be fully rated for available interrupting current. (Series rated is not acceptable.)

d. Phase, Neutral and Ground Buses shall be hard-drawn copper 98% conductivity. (Aluminum is not acceptable.)

e. Breakers shall indicate tripped condition by a means other than the off position.

f. Hinged-to-box (tub), front door construction.

g. Panelboards shall be equipped with 20% spare breakers. A/E shall note that it is not the intention of this guideline to provide an extra panelboard just to meet this requirement.

h. Panelboards shall be fully bussed with mounting brackets for all positions including spaces.

9. Identification

a. Refer to Panelboard naming convention in Common Work Results for Electrical Design Standards.

10. Provide working space per City of Chicago Code.

M) ELECTRICAL SYSTEMS

m. Motor Control Centers

- 1. Summary: This section contains design criteria for Motor Control Centers for use on ac circuits rated 600V and less.
- 2. Sustainability: General applicable items include regional manufacturers, recycled / American steel and copper and manufacturers use of low VOC coatings.
- 3. Design and Performance Requirements
 - a. Motor Control Centers shall be located in electrical equipment rooms or other equipment rooms designed for such. Access to rooms shall be accessible to qualified personnel only.
 - b. Phase, Ground and Ground Buses shall be hard-drawn copper 98% conductivity. (Aluminum is not acceptable.)
 - c. Design motor control centers and their components with short circuit rating of not less than 42,000AIC.
 - d. Units that are size 3 and above shall have draw-out mountings.
 - e. Individual feeder-tap units through 225A shall have draw-out mountings.
- 4. Enclosures; rated for environmental conditions as follows:
 - a. Indoor Locations: NEMA 250, Type 1
 - b. Wet or Damp Indoor Locations: NEMA 250, Type 4
 - c. Enclosure shall be painted with manufacturer's standard grey finish.
- 5. Quality Assurance
 - a. Electrical components, devices and accessories shall be listed and labeled by a testing agency acceptable to the Authority Having Jurisdiction and marked for intended use.
 - b. Warranty shall be manufacturer's standard or 12 months; whichever is greater.
- 6. Project Conditions:
Provide minimum seven (7) days notice to Owner's Designated Representative of a proposed interruption of electrical service.

7. Manufacturers:

- a. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary
- b. Eaton Corporation; Cutler-Hammer Products
- c. General Electric Co.; GE Industrial Systems
- d. Rockwell Automation Allen-Bradley Co.; Industrial Control Group
- e. Siemens/Furnas Controls.
- f. Square D; Schneider Electric

8. Identification: Refer to Equipment naming convention in Common Work Results for Electrical Design Standards.

n. Enclosed Bus Assemblies

- 1. Summary: This section contains design criteria for Feeder-bus assemblies, Plug-in bus assemblies and Bus plug-in devices.
- 2. Sustainability: General applicable items include regional manufacturers, recycled / American steel and copper and manufacturers use of low VOC coatings.
- 3. Quality Assurance
 - a. Electrical components, devices and accessories shall be listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, UL listed and marked for intended use.
 - b. Comply with NEMA BU 1, "Busways".
- 4. Extra Materials
 - a. Provide additional plug-in units equal to 10 percent of amount installed but no fewer than 2 units.
 - b. Provide hookstick operator for plug-in units.
- 5. Manufacturers
 - a. Eaton Corp.; Cutler Hammer Products
 - b. General Electric Company; Electrical Distribution & Control Division
 - c. Siemens Energy & Automation, Inc.
 - d. Square D; Schneider Electric
- 6. Bus Assemblies
 - a. Weather proof steel enclosure with manufacturer's standard enamel finish, sealed seams and drains with removable closures.
 - b. Phase, Neutral and Ground Buses shall be copper. (Aluminum is not acceptable.)
- 7. Plug-in Devices: Plug-in units shall be hookstick handle operated, circuit breaker type with common trip for all poles.

M) ELECTRICAL SYSTEMS

o. Wiring Devices

- 1. Summary: This section contains design criteria for receptacles, ground-fault circuit interrupters, integral surge suppression units and isolated-ground receptacles in addition to snapswitches, dimmer switches, device wall plates, floor service outlets, poke-through assemblies, service poles and multi-outlet assemblies.
- 2. Sustainability: There are not any specific sustainability requirements associated with this section.
- 3. Quality Assurance: Electrical components, device and accessories shall be listed and labeled as defined in NFPA, Article 100, by Underwriters Laboratories and marked for intended use.
- 4. Receptacles
 - a. Isolated-ground Receptacles shall be listed and labeled as isolated-ground receptacles.
 - b. Isolation method shall be integral to receptacle construction and not dependent on removable parts.
 - c. Use of an isolated equipment grounding conductor does not relieve the requirement for grounding the raceway system and outlet box.
 - d. For healthcare facilities (i.e., hospitals, outpatient clinics, healthcare centers, etc.), if a receptacle is supplied from the emergency system, it or its cover plate shall have a distinctive color or marking to be readily identifiable. If color is used to identify these receptacles, use the same one throughout the facility. Red is commonly used for this application. However, orange has been used in some facilities where red was selected for use on the fire alarm circuits. In general, the components of the essential electrical system, with the exception of the alternate source of supply and transfer switches, are the same as those in the normal distribution system.

- 5. Finishes: Wiring devices connected to normal power systems shall be as selected by owner unless otherwise indicated or required by City of Chicago Electrical Code.
- 6. Manufacturers
 - a. Cooper Wiring Devices; a division of Cooper Industries, Inc.
 - b. Hubbell Incorporated; Wiring Device-Kellems
 - c. Leviton Mfg. Compayn Inc.
 - d. Pass & Seymour/Legrand; Wiring Devices & Accessories
- 7. Provide basis of design device listed below or equal by approved manufacturers.
 - a. Receptacles (125V, 20A unless otherwise noted)
 - i. Straight Blade Convenience Receptacle – Hubbell HBL5362
 - ii. Straight Blade Hospital-Grade Receptacle – Hubbell HBL8300H
 - iii. Straight Blade Isolated-Ground Receptacle – Hubbell CR5352IG
 - iv. Straight Blade Tamper-Resistant Receptacle – Hubbell HBL8300SG
 - v. GFCI Convenience Receptacle – Hubbell GFR5352L
 - vi. GFCI Hospital-Grade Receptacle – Hubbell HGF8300
 - vii. TVSS Convenience Receptacle – Hubbell HBL5362SA
 - viii. Twist-Locking Receptacle – Hubbell HBL2310
 - b. Snap Switches (120/277 V, 20A)
 - i. Single Pole Switch – Hubbell HBL1221
 - ii. Pilot Light Switch – Hubbell HPL1221PL
 - iii. Key-Operated Switch – Hubbell HBL1221L
 - c. Double-Throw, Momentary Contact, Center-Off Switches
 - i. Single-Pole – Hubbell HBL1557
 - ii. Key-Operated, Single-Pole – Hubbell HBL1557L

p. Enclosed Switches and Circuit Breakers

- 1. Summary: This section contains design criteria for individually mounted, safety disconnect switches, molded-case circuit breakers rated at 600 Volts or less, low-voltage power circuit breakers.
- 2. Sustainability: There are not any specific sustainability requirements associated with this section.
- 3. Submittals
 - a. For each type of enclosed switch, circuit breaker, accessory and component indicated. Include dimensioned elevations, sections, weights, shipping configuration and manufacturers' technical data on features, performance, electrical characteristics, ratings and finishes.
- 4. Quality Assurance: Electrical components, devices and accessories shall be listed and labeled as defined in NFPA 70, Article 100, by Underwriters Laboratories and marked for intended use.
- 5. Cleaning: Inspect exposed surfaces and repair damaged finishes.

M) ELECTRICAL SYSTEMS

- q. **Variable-Frequency Motor Controllers**

1. Summary: This section contains design criteria for separately enclosed, pre-assembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

2. Sustainability: There are not any specific sustainability requirements associated with this section.

3. Enclosures:

a. Shall be NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at the installed location.

b. Provide (2) normally open and (2) normally closed auxiliary control relay contacts.

c. Provide Integral cooling fans and filters within enclosure.

4. Integral Disconnect, Isolating Switch and Isolated Bypass

a. All VFDs shall be equipped with an integral disconnect switch.

b. All VFDs shall be equipped with an isolated service bypass.

c. All VFDs shall be equipped with an isolating switch to permit safe troubleshooting and testing while energized and de-energized while motor is operating in bypass mode.

5. Power and Control Wiring: All power and control wiring shall be routed in separate metallic conduits.

6. Factory Startup Service: Provide VFD system startup and training to be performed by factory-authorized service representative.

7. Manufacturers

a. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary

b. Square D; Schneider Electric
- r. **Variable Frequency Driven Motors – Induced Voltage Bearing Current Mitigation Strategies**

1. All motors operated on variable frequency drives (VFD) shall be equipped with a maintenance free, conductive micro fiber, shaft grounding ring (SGR) with a minimum of two (2) rows of circumferential micro fibers to discharge electrical shaft currents within the motor and/or bearings.

2. All motors up to 200HP shall be provided with a minimum of 1 shaft grounding ring (SGR) installed on the drive/shaft end (preferably) or non-drive end.

3. All motors 250HP and above shall be provided with an insulated bearing on the non- drive end and a shaft grounding ring (SGR) on the drive/shaft end of the motor.

4. All shaft grounding rings (SGR) shall be provided and installed by the motor manufacturer or contractor and shall be installed in accordance with manufacturer’s recommendations,

5. Approved Manufacturer (SGR):

a. AEGIS—SGR Bearing Protection Ring
- s. **Engine Generators**

1. Summary: This section contains design criteria for Natural Gas and Diesel Engine Generators.

2. Sustainability: There are not any specific sustainability requirements associated with this section.

3. Design Intent

a. Code required generators: Locate indoor generators within separate 3 hour fire rated room.

b. Load bank testing: Provide exterior connection for outdoor portable load bank testing to indoor generators.

c. Provide monitoring connection to the University B.A.S. Refer to B.A.S design standards section.

d. Provide convenient and accessible means of refueling generator day tanks and sub-base mounted tanks.

e. Natural Gas Generators are preferred for University projects. Main gas line service from Peoples Gas shall be a “dedicated” service, supplying only the life safety/optional standby generator.
4. Quality Assurance

a. Installer Qualifications

i. Maintenance Proximity: Not more than two (2) hours normal travel time from Installer’s place of business to project site.

b. Manufacturer Qualifications

i. A qualified manufacturer shall maintain, within 100 miles of project site, a service center capable of providing training, parts and emergency maintenance repairs.

ii. Provide 1 year full maintenance by skilled employees of manufacturer’s designated service organization and coordinate rollover to University’s maintenance contractor at end of term.

c. Comply with NFPA 110 and City of Chicago requirements for Level 1 and/or 2 emergency power supply systems.
5. Manufacturers

a. Caterpillar Engine Division

b. Onan Corp./Cummins Power Generation; Industrial Business Group

c. Kohler Co.; Generator Division

d. MTU Onsite Energy

e. Inland Detroit Diesel

M) ELECTRICAL SYSTEMS

6. Fuel Supply System

a. Natural Gas: Provide “dedicated” service from Peoples Gas

b. Diesel

i. Comply with NFPA 30, NFPA 54 and City of Chicago Code.

ii. Day Tank shall comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:

· Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.

· Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of 4 hours operation at 100 percent of rated power output of engine generator system without being refilled.

· Pump capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.

· High-level alarm sensor: Liquid-level device operates alarm and redundant fuel shut off contacts at midpoint between overflow level and 100 percent of normal fuel level.

· Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine-generator set.

· Provide leak detection in interstitial space and connect to provide audible and visual alarms in the event of a leak.

c. Base-Mounted Fuel Oil Tank shall be factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:

i. Tank level indicator.

ii. Fuel capacity for four (4) hours’ continuous operation at 100 percent rated power output.

iii. Vandal-resistant fill cap.

iv. Containment Provision shall comply with requirements of authorities having jurisdiction.

7. Field Quality Control

a. Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

t. Static Uninterruptible Power Supply

1. Summary: This section contains design criteria for three phase, on-line, double conversion, static type UPS units.

2. Sustainability: There are not any specific sustainability requirements associated with this section.

3. Design Intent

a. Include proper ventilation in battery rooms.

b. Provide connection to University B.A.S. for monitoring. Refer to B.A.S. facility standards for additional information.

4. Modes of Operation:The UPS shall be designed to operate as an on-line reverse transfer system in the following modes:

a. Normal: The UPS inverter continuously supplies the critical AC load. The recitifier/charger derives power from a utility AC source and supplied DC power to the inverter while float-charging a power reserve battery.

b. Emergency: Upon failure of utility AC power, the critical AC load is supplied by the inverter, which without any switching, obtains power from the battery. There shall be no interruption in power to the critical load upon failure or restoration of the utility AC source.

c. Recharge: Upon restoration of utility AC power the rectifier/charger shall automatically restart, walk-in and gradually assume the inverter and battery recharge loads.

d. Bypass: If the UPS must be taken out of service for maintenance or repair or should the inverter overload capacity be exceeded, the static transfer switch shall perform a reverse transfer of the load from the inverter to the bypass source with no interruption in power to the critical AC load.

5. Manufacturers

a. Liebert Corporation; a division of Emerson

b. MGE UPS Systems

c. Exide Electronics; Powerware

d. Mitsubishi Electric Automation Div.

e. Eaton Corp.; Cutler-Hammer Products

The Facilities Services Facility Standards (FS)² is a living document, which is subject to change. Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

THE UNIVERSITY OF CHICAGO FACILITIES SERVICES

FS² Volume III - Design Requirements | Page 214

M) ELECTRICAL SYSTEMS

- u. **Transfer Switches**

 1. Summary: This section contains design criteria for transfer switches, manual bypass or isolation switches rated 600V and less.
 2. Sustainability: There are not any specific sustainability requirements associated with this section.
 3. Design Intent
 - a. Code required emergency systems: Locate transfer switches and associated distribution equipment within a separate 2 hour fire rated room from Utility Power.
 - b. Provide switched neutral for 3 phase, 4 wire, automatic transfer switches.
 - c. Provide In-Phase Monitor for transfer of power between normal and emergency sources only when both sources are synchronized in-phase within 15 electrical degrees and only if transfer can be completed within 60 electrical degrees.
 4. Quality Assurance: Electrical components, device and accessories shall be listed and labeled as defined in NFPA 70, Article 100, for emergency service under UL 1008, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
 5. Submittals
 - a. Submit shop drawings with wiring diagrams, product data and parts list.
 - b. Submit qualification data for manufacturer and testing agency.
 - c. Submit operations and maintenance instructions.
 6. Manufacturers
 - a. Caterpillar, Engine Division
 - b. Emerson, ASCO Power Technologies, LP
 - c. GE Zenith Controls
 - d. Onan Corp/Cummins Power Generation, Industrial Business Group
 - e. Russelectric, Inc.
- v. **Transient-Voltage Suppression for Low-Voltage Electrical Power**

 1. Summary: This section contains design criteria for Surge Protection Devices (SPDs) for low-voltage (120 to 600 V) power distribution and control equipment.
 2. Sustainability: There are not any specific sustainability requirements associated with this section.
 3. Provide only UL Listed Surge Protection Devices.
 4. Service Entrance Suppressors – Type 1
 - a. The following construction features are not acceptable
 - i. Plug-in component modules in the primary transient path will not be accepted.
 - ii. Equipment that creates hazard upon failure will not be accepted.
 - iii. Suppressors that rely on other external or upstream units to achieve the required performance and UL 1449 listing will not be accepted.
 - iv. Suppressors that employ cartridge fuses will not be accepted.
 5. Panelboard Suppressors – Type 2
 - a. The following construction features are not acceptable
 - i. Plug-in component modules in the primary transient path will not be accepted.
 - ii. Equipment that creates hazard upon failure will not be accepted.
 - iii. Suppressors that rely on other external or upstream units to achieve the required performance and UL 1449 listing will not be accepted.
 - iv. Suppressors that employ cartridge fuses will not be accepted.
6. Installation of surge protection devices
 - a. Install Type 1 devices at switchboard on load side, with ground lead bonded to service entrance ground.
 - b. Install Type 2 devices for panelboard with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer’s recommended lead length. Do not bond neutral and ground.
 - c. Provide multi-pole circuit breaker as shown on the One Line Diagram as a dedicated disconnect for suppressor, unless otherwise indicated

M) ELECTRICAL SYSTEMS

w. Interior Lighting

- 1. Summary: This section contains design criteria for interior lighting fixtures with lamps and ballasts. It also includes preferred practices for lighting retrofits within campus buildings. The University recognizes the significant impact on both energy consumption and costs that lighting represents in buildings. Therefore, the University is interested in progressive technology, such as LED lighting, to reduce these impacts. Any such technology will be readily considered for projects as long as quality and costs are acceptable. All applicable building codes shall be referenced during the lighting design process. If there are any disparities between the requirements in this document and the buildings code, then the building code shall take precedence.
- 2. Sustainability: Applicable items include regional manufacturers, energy efficient fluorescent lamp technology and the use of natural day lighting in design methods.
- 3. Design and Performance Requirements
 - a. Lighting technology and especially LED lighting technology is a developing industry. Lighting designs must incorporate the latest proven technologies in an effort to increase energy savings and decrease early obsolescence of the lamps and fixtures.
 - b. Design interior lighting levels in the following spaces to the IES footcandle values as listed below. Deviations are allowed from these levels as long as there is a justifiable reason.

x. Exterior Lighting

- 1. Summary
 - a. This section contains design criteria for exterior luminaries with lamps and ballasts.
- 2. Sustainability
 - a. Applicable items include regional manufacturers, energy efficient fluorescent lamp technology and reduction of night sky light pollution and light trespass in design practices.
- 3. Design and Performance Requirements
 - a. Lighting technology and especially LED lighting technology is a fast, aggressively developing industry. Lighting designs must incorporate the latest proven technologies in an effort to increase energy savings and decrease early obsolescence of the lamps and fixtures.
 - b. Design exterior lighting levels in the following areas to the IES footcandle values as listed below:

Outdoor Area Description	
Building Entrances	5
Prominent Structures	5
Pedestrian Malls	5
Gardens - Focal Points	5
Gardens - General Lighting	3
Retail Areas	10

- c. High Intensity Discharge lamp ballasts shall be pulse start where available and probe start otherwise.
 - d. Minimum starting temperature shall be minus 22 degrees F for single lamp ballasts.
 - e. Fluorescent lamps shall have minimum CRI 80 and color temperature of 3500K.
 - f. High pressure sodium lamps shall have minimum CRI 21 and color temperature of 1900K.
 - g. Metal halide lamps shall have minimum CRI 65 and color temperature of 4000K.
 - h. Mount fixtures so hinged panels swing to allow access by maintenance personnel.
 - i. Exterior lighting design shall comply with IECC wherever applicable.
 - j. Refer to Site Lighting standards for additional information.
4. Manufacturers
- a. Cooper Lighting: Lumark or McGraw Edison
 - b. Hubbell
 - c. Lithonia
 - d. Spero

M) ELECTRICAL SYSTEMS

y. Emergency Lighting

- 1. Summary
 - a. This section contains design criteria for Emergency Lighting, Exit Signs and Battery Inverter Ballasts.
- 2. Sustainability
 - a. Applicable items include regional manufacturers and energy efficient fluorescent lamp technology.
- 3. Design and Performance Requirements
 - a. Emergency Lighting
 - i. Emergency lighting shall be powered by generator when available. If generator power is not an option then integral emergency inverter ballast with sufficient capacity to provide 90 minutes of emergency power will be provided.
 - ii. Emergency lighting to be configured such that 1 lamp operates continuously and the unswitched circuit is connected to battery inverter and switched circuit is connected to the fixture ballast.
 - iii. Emergency lighting shall be equipped with Push to test button to simulate loss of normal power and integral self-diagnostics which automatically initiates code required test of unit at required intervals. Test failure is indicated by audible alarm and flashing red LED.
 - b. Exit Signage
 - i. LED lamps shall be the standard preferred lamp in all Exit signage.
 - ii. The University standard color for all Exit Signage lettering shall be Red.
 - iii. Exit signage shall be powered by generator when available. If generator power is not an option then integral emergency inverter ballast with sufficient capacity to provide 90 minutes of emergency power will be provided.
 - iv. Exit sign shall be equipped with Push to test button to simulate loss of normal power and integral self-diagnostics which automatically initiates code required test of unit at required intervals. Test failure is indicated by audible alarm and flashing red LED.

c. Battery Inverter Ballast

- i. Emergency lighting battery shall be sealed, maintenance-free and nickel cadmium type.
- ii. Exit Signage battery shall be sealed, maintenance-free and nickel-cadmium type.

4. Manufacturers

a. Emergency Lighting - Battery Inverters

- Bodine
- Iota Engineering
- Lithonia Power Sentry

b. Exit Signage

- Chloride Systems
- Cooper Industries, Inc.; Sure-Lites Division
- Hubbell, Inc.; Dual-Lite
- Lithonia Lighting, Emergency Lighting Systems
- Thomas & Betts Corporation; Emergi-Lite Corporation Division

3. REFERENCES

All electrical components, devices and accessories installed shall be listed and labeled as defined in NFPA 70, Article 100, by Underwriters Laboratories and marked for intended use. Always comply with City of Chicago Electrical Code, NFPA, NEC and all other applicable building codes.

The latest edition of the following codes and standards shall apply:

- National Fire Protection Association (NFPA)
- National Electrical Code (NEC)
- The City of Chicago Electrical Code
- Occupational Safety and Health Act (OSHA)
- Underwriters Laboratory (UL)
- Institute of Electrical and Electronics Engineers (IEEE)
- Illuminating Engineering Society of North America (IESNA)
- National Electrical Manufacturers Association (NEMA)
- American National Standards Institute (ANSI)
- FM Global

N) FIRE PROTECTION SYSTEMS

1. Introduction

The following Fire Protection Systems Standards provide requirements and guidelines for use by the Consultant in the design and construction of fire alarm and suppression systems at the University of Chicago.

General Design Requirements

This standard applies to the design and installation of fire alarm and sprinkler systems, including equipment for new building construction, replacement of existing systems with new systems in existing buildings, and modifications to existing systems.

- It is expected that the project design follow all applicable FM Global Property Loss Prevention Data Sheets (Engineering Guidelines). The FS Project Manager will coordinate the review of system designs with FM Global.
- All new fire alarm systems shall be analog addressable systems with alarm verification features for all smoke detection. The system shall be a voice/speaker based system with Chicago Class 1 characteristics. All new fire sprinkler systems shall be installed and connected to the addressable fire alarm systems.
- It is not acceptable to provide a new panel and/or equipment to serve a portion of a building unless the new panel and/or equipment are fully compatible with the existing system and listed to function as a single networked system. When older systems cannot be expanded to serve a renovated space, a new fire alarm panel should be provided for the entire building. Hybrid systems supporting new and old technology will not be permitted unless approved by the University.

- Where existing fire alarm or sprinkler systems are upgraded or replaced, the existing system shall remain in service until the new system is operational and final acceptance has been conducted by the University. Procedures for identifying existing devices and circuits to be connected to the new system, if required and the cut over of the existing fire alarm service to the new fire alarm system shall be included in the construction documents.
- If an existing fire alarm or sprinkler system is to be out of service for more than 4 hours during a normal work day, an approved fire watch will be required. If an existing fire alarm system is to be out of service during an after-hours period, an approved fire watch will be provided until service is restored.

System Design Compliance and Certification

Fire alarm designs shall be completed by an individual holding a NICET III (minimum) Fire Alarm Certification, and under the supervision of a licensed Professional Engineer. Fire sprinkler designs shall be completed under the supervision of a by a licensed Professional Engineer or qualified sprinkler contractor with a NICET certification, Fire Sprinkler Certification.

- The Consultant shall remain responsible for the final design of the fire alarm system. Nothing in this standard, including comments generated by the University staff and its agents, shall absolve the design consultant of this responsibility. Any conflicts between these standards and current codes in affect shall be brought to the University’s attention.
- The Consultant shall adhere to this standard. Should a specific situation arise where the system designer believes that a variance from these standards is warranted, permission must be obtained from the University.
- The Chicago Building Code Occupancy classification shall be provided by the University. The classification shall be reviewed with the University if during the design process the design consultant believes it is incorrect.

VOLUME III – DESIGN REQUIREMENTS

N) FIRE PROTECTION SYSTEMS

2. Fire Protection Design Process

Process Phase	Fire Protection Objective
Programming	Determine scope of Fire Protection systems in response to Owner’s Project Requirements.
Schematic Design	The design consultant shall complete a survey of the building to verify the existing system as installed. This survey shall include verification as to the type of the system or device installed and its location. The actual room usage shall be documented and compared to any room usage lists generated by the University. The actual documented room usage shall take precedent with regard to system design. Fire and smoke barriers shall be determined as well.
Schematic Design	A meeting shall be scheduled with the FS Project Manager and the Building Users where the fire protection system is to be installed. The purpose of this meeting is to review and discuss the impact of the system design and installation on the physical building. The meeting shall document the following: • To establish the location of all major fire alarm equipment such as control panels and annunciators. • To establish the location of all major fire sprinkler equipment such as: i. Fire pumps ii. Inspectors test stations iii. Fires stand pipes iv. Auto sprinkler risers v. Siamese connections on the exterior of the building vi. Any other items that will impact the building’s appearance • The extent of detector or sprinkler coverage beyond the Chicago Building Code minimum requirements shall be established. This determination shall be made based on the following considerations: i. Building use and contents ii. Historical significance iii. Occupant load iv. Type of construction v. The installation of approved sprinkler systems • The discussion shall include the type of initiating or sprinkler devices to be employed for the areas to be protected as the type of device will have an impact on maintenance and cost. • Issues and concerns the Users and/or University may have with the existing and proposed fire alarm or sprinkler system. • Proposed construction schedule and the impact on the building occupants. • Testing and acceptance of the system shall be discussed to establish what testing must be conducted outside of the normal work day. The costs for all premium time testing to include final acceptance testing shall be included in the construction documents.
Schematic Design	Hydrant flow test shall be ordered.
Schematic Design	Layout of major equipment and fire sprinkler /standpipe mains • Major Horizontal fire sprinkler/standpipe bulk mains • Auto Sprinkler Riser (ASR) i. Auto sprinkler riser shall be located within the building, location to accommodate Fire Department Test and Drain Riser i. Drain riser shall be located within the building, and shall be piped to the exterior of the building • Fire Standpipe (FSP) i. Based upon the buildings height, determine if fire standpipe system will be required ii. Determine number and locations of fire standpipe/s. • Fire pump (FP) i. Based upon any available information, determine the need for fire pump. ii. Determine preliminary location of proposed fire pump, if pump is to be placed within an existing building. • Siamese Connections i. Determine preliminary location of proposed fire department Siamese connections • Inspection and Test Valve (ITV) i. Shall be included at farthest/highest point of the system.
Design Development	Submission shall be made at the completion of the design development phase. This submission shall include: • A complete set of preliminary specifications for the fire alarm or sprinkler work to be accomplished. These specifications shall include all sections required to accomplish the work included in the project. • A complete set of floor plans identifying the location of all initiating and notification devices and other fire alarm or sprinkler equipment. A basic fire alarm and sprinkler riser diagram shall be included. Proposed vertical riser raceway locations shall be identified on the floor plans. • The fire alarm system design shall interface with existing building equipment related to or desired to be controlled by the fire alarm system. The sprinkler system design shall interface with other interlocked systems. The Consultant shall include in the design all work necessary to interface HVAC shut-down, sprinkler monitoring and control, building systems such as access control release, smoke management and other code specified supervisory functions. Any equipment, wiring, installation or other work necessary to finish all interface and output wiring or equipment shall be included in the design and subsequent bid packages.

VOLUME III – DESIGN REQUIREMENTS

N) FIRE PROTECTION SYSTEMS

2. Fire Protection Design Process

Process Phase	Fire Protection Objective
Design Development	FM Global: Automatic Sprinkler Protection Submittals: Automatic sprinkler protection plan submittals should consist of the following items (confirm with FS Project Manager): • Fire Protection Drawings of the proposed system(s). At minimum, submitted fire protection drawings shall include: i. Piping layout and sizes ii. Location and number of sprinklers (with fire sprinkler identification numbers (SIN) clearly indicated on the drawings). iii. Location of remote area used in hydraulic calculations • Hydraulic Calculations • Specifications for materials being used, including but not limited to: i. Sprinkler heads ii. Sprinkler pipe iii. Sprinkler control valves iv. Any peripheral equipment – including tamper alarms, water flow alarms, etc. • Occupancy Details: in order to review submitted plans to ensure adequate protection, accurate occupancy detail must be provided. This would include a general description of the area being protected and, in case of dedicated storage areas details of the materials being stored, storage height, storage arrangement, etc. should be provided.
Construction Documents	A A formal submission shall be made to the University’s Risk Management, Audit and Safety Department for review by the University’s insurance underwriter. • This submission will typically be 80% of the construction documents. This submission may be combined with the final construction document submission for small projects. • This submission will consist of a complete set of fire alarm drawings and specifications. • Formal review comments will be provided by the insurance company. The Consultant shall incorporate these comments into the drawings to the extent possible while keeping with sound engineering judgment and a detailed knowledge of the project as a whole. The Consultant will reconcile these comments with FS Project Manager in writing.
Construction Documents	Submission shall be at the completion of the construction document phase. This submission shall include: • A complete set of specifications to include all sections required to complete the required scope of work. • A complete set of drawings identifying the scope of work. • Fire alarm drawings shall include: i. Floor plans identifying the placement of all initiating and notification devices as well as other required fire alarm equipment such as control and voice panels, annunciators remote power supplies and city tie boxes when required. ii. The location of all vertical fire alarm riser raceways. iii. Installation details. iv. The final sequence of operation. This sequence shall be identified using an Input/output matrix. • Fire Sprinkler drawings shall include: i. Floor plans identifying the placement of: a. Location of fire protection equipment b. Location of all fire sprinkler standpipe systems c. Location of all bulk mains d. Location of auto sprinkler risers e. Location of test and drain risers. ii. Installation details. a. General project related details b. Specific project related details iii. Riser diagrams a. Fire protection stand pipe and Auto sprinkler risers
Construction	Shop drawings prepared by the fire alarm vendor shall be provided to the University FS group for review and comment. The shop drawings shall be prepared by a NICET III (minimum) Fire Alarm Certified individual. The shop drawings will include evidence of review by the Consultant prior to submitting to the University.
Construction/Closeout	Prior to acceptance testing, the installing contractor will submit the following: • The supervising installer will complete the “Fire Alarm record of Completion” form as described in NFPA-72 prior to scheduling the acceptance testing. • Equipment installation manual, operating, maintenance, programming, parts and repair manuals. • Spare equipment required by contract with inventory list. • Testing and maintenance schedule. • Completed as built drawings.

N) FIRE PROTECTION SYSTEMS

3. SYSTEM GUIDELINES

a. Fire Alarm System

1. All new fire alarm systems installed shall be an analog addressable system. The system and components shall be by a single manufacturer. The following system manufacturers are currently approved for use in new installation or complete replacement projects:

- a. Notifier by Honeywell
- b. EST by Edwards
- c. Gamewell/FCI
- d. Siemens

For projects that involve modifying or expanding an existing system, all new equipment shall be compatible with the existing manufacturer’s system. This requirement shall have precedence over using the preferred manufacturers listed above.

2. The installation of the fire alarm system shall be supervised by a NICET Level III (minimum) certified technician. The electrical contractor shall have this individual on staff or be contractually supported by a company with such an individual. The contractors shall provide the qualification data for the supervising individual.

3. All concealed fire alarm raceways and exposed raceways in unfinished spaces shall be red. Back boxes shall have red cover plates permanently identified with FA on the plate. Exposed raceways in finished spaces shall be painted to match the surface to which it is mounted. All raceways shall be installed concealed unless approved b the University.

4. Fire alarm systems manual pull stations shall be single action. Pull stations installed within occupancies where children are present shall be provided with a plastic protective shield with electronic sounder.

5. The fire alarm control panel (FACP) shall be used to control pre-action systems. The FACP shall be UL listed to perform this function.

6. All concealed duct mounted smoke detectors shall be provided with a remote indicator device. Remote test switches shall be provided.

7. All initiating devices to be permanently labeled with the device address using an adhesive label.

8. All notification circuits shall be Class A. Signaling circuits in non-city required buildings shall be installed as Class A.

9. The FACP shall be provided with test/bypass switches to permit testing of the complete system with minimal disruption to the building occupants. Required test/bypass switches will include at a minimum the following:

- a. Elevator recall
- b. Notification device
- c. AHU shutdown
- d. Smoke damper closure
- e. Electric lock release
- f. Pre-action system release
- g. Electric door hold open release
- h. Sprinkler system bypass - flow switches, tamper switches, and fire pump run

10. Systems installation shall include an exterior mounted red rotating beacon to be located at the building’s main entrance. Location of the beacon shall be coordinated with the University.

11. The building shall be interconnected to the University’s Police Department fire alarm receiving station. The fire alarm design and installation shall include all digital alarm communicators and equipment to complete the remote station service. The design consultant shall coordinate phone line service with Capital Project Delivery Project Manager.

12. All fire alarm systems shall be provided with a three year manufacturer’s warranty (minimum).

13. The construction documents shall include spare components to be turned over to the FS Project Manager upon completion of the project. The following shall be included at a minimum:

- a. Two smoke detectors of each type used on the project.
- b. One heat detector of each type used on the project.
- c. One manual pull station.
- d. Two audio devices of each type used on the project.
- e. Two visual devices of each type used on the project.
- f. One interface module of each type used on the project.
- g. One duct detector housing and remote indicator and test switch.
- h. Metal wall cabinet to store the devices in each facility.

N) FIRE PROTECTION SYSTEMS

b. Fire Sprinkler System

- 1. The following system or component manufacturers are approved for use in new installation or replacement projects:
 - a. Grooved fittings, UL listed, FM approved
 - i. Gruvlock
 - ii. Vitaulic
 - b. Schedule 40 pipe, ASTM A53, ASTM A135
 - c. Schedule 10 pipe, ASTM A135
 - d. Backflow preventers
 - i. Watts
 - ii. Wilkins
 - iii. Febco
 - e. Fire sprinkler components
 - i. Reliable Sprinkler
 - ii. Viking Sprinkler
 - iii. Tyco
 - f. Clean agent gas systems FE25, FM200, FE227
 - i. Du Pont
 - ii. Fike
 - iii. Great lakes
 - g. Nitrogen generation system
 - i. Corrosion Solutions
 - h. Corrosion monitoring station
 - i. Corrosion Solutions
 - i. Fire pumps
 - i. Patterson Pump Company
 - ii. Peerless Pump
 - iii. Aura Fairbanks
 - j. Fire pump controllers
 - i. Firetrol
 - ii. Cutler-Hammer
 - iii. Master

- 2. The following piping requirements are to be provided upstream of backflow preventers:
 - a. Pipe
 - i. Schedule 40 galvanized steel
 - ii. Ductile iron pipe
 - b. Fittings
 - i. Roll grooved
 - ii. Cut grooved
 - iii. Mechanical joint
 - iv. Welded and threaded
 - c. Valves
 - i. Minimum pressure rating: 175 psig
- 3. The following piping requirements apply downstream of backflow preventers:
 - a. Pipe
 - i. Schedule 10 black steel pipe
 - ii. Schedule 40 black steel pipe
 - b. Fittings
 - i. Roll grooved
 - ii. Cut grooved
 - iii. Threaded
 - iv. Welded and threaded cast iron
 - c. Valves
 - i. Minimum pressure rating: 175 psig

- 4. The following piping requirements apply for interior installations:
 - a. Pipe
 - i. Schedule 10 black steel pipe
 - ii. Schedule 40 black steel pipe
 - b. Fittings
 - i. Roll grooved for Schedule 10 or 40. Coordinate pressure ratings with fire pump discharge pressure.
 - ii. Cut grooved for Schedule 40. Coordinate pressure ratings with fire pump discharge pressure.
 - iii. Copper
 - iv. Threaded
 - v. Welded and threaded cast iron
 - c. Valves
 - i. Minimum pressure rating: 175 psig. Coordinate pressure ratings with fire pump discharge pressure.
 - ii. Minimum pressure rating: 250 psig. Coordinate pressure ratings with fire pump discharge pressure.
- 5. The following piping requirements apply for exterior installations:
 - a. Pipe
 - i. Schedule 40 black steel pipe
 - b. Fittings
 - i. Roll grooved
 - ii. Cut grooved
- 6. The following piping requirements apply for dry sprinkler systems:
 - a. Pipe
 - i. Schedule 40 galvanized pipe
 - b. Fittings
 - i. Roll grooved
 - ii. Cut grooved
 - iii. Welded joints are not acceptable

N) FIRE PROTECTION SYSTEMS

7. The following piping requirements apply for clean agent systems:
 - a. Pipe (Per manufacturer's requirements for applicable pressures)
 - i. Schedule 40
 - ii. Schedule 80
 - iii. Schedule 160
 - b. Fittings(Per manufacturer's requirements for applicable pressures)
 - i. Threaded Class 300
 - ii. Threaded Class 600
 - iii. Forged steel welded fittings Class 3000
8. Backflow preventers:
 - a. Reduced Pressure Principle
 - i. Configuration – Horizontal
 - ii. Bypass with displacement-type water meter, shut off valves and reduced pressure principle backflow preventer
 - iii. Pressure loss to be no greater than 15 psig throughout its operating range.
 - b. Double-Check
 - i. Configuration – Horizontal
 - ii. Bypass with displacement-type water meter, shut off valves and double-check backflow preventer.
 - iii. Pressure loss to be no greater than 7 psig throughout its operating range.
9. Wet pipe sprinkler systems:
 - a. Pipe shall be coated on the interior by the manufacturer to provide resistance to microbiologically influenced corrosion (MIC).
 - b. Provide automatic air vents to vent trapped air in a wet pipe sprinkler system.
 - c. Provide Corrosion Monitoring Station, designed to monitor internal corrosion activity in a water based fire protection system.
10. Dry pipe sprinkler systems:
 - a. Pre-packaged, cabinet mounted dry pipe valve/system, including fractional hp air compressor.
 - b. Nitrogen generation system, connected to the air supply serving the dry pipe system. System shall vent oxygen rich air out of the system in order to achieve a 95% or greater concentration of nitrogen into the system.
11. General sprinkler installation requirements:
 - a. Rooms without ceilings: upright heads
 - b. Suspended Ceilings: recessed pendent sprinklers, including escutcheons (phantom)
 - c. Main electrical rooms shall not be sprinkled by either a wet or a dry system. Main electrical rooms will have heat and smoke detection only.
 - d. Provide extra stock of sprinklers and wrench for each type of sprinkler. Quantity per code for each type.
12. Exposed pipe installations:
 - a. All exposed pipe shall be painted.
13. Fire pump:
 - a. Electric Drive, Centrifugal
 - i. Ensure 100 PSI at the most remote and tallest building fire standpipe termination.
 - ii. Inlet/outlet flange rated to meet the inlet and outlet pressures anticipated.
 - iii. Voltage shall be determined by Electrical Engineer.
 - iv. Controller solid state soft start with transfer switch to emergency power.
 - v. Ensure proper ventilation.
 - vi. Pump shall be located in dedicated fire pump room.

N) FIRE PROTECTION SYSTEMS

c. Testing and Acceptance

1. Final acceptance testing shall be performed by the installing contractor at the direction of the University FS Project Manager. The system shall be completely operational, finished and ready for acceptance testing in accordance with the anticipated project schedule. The FS Project Manager and EHS representative will be notified 10 working days in advance of the proposed date for acceptance testing
2. Acceptance test procedure:
 - a. Final acceptance testing shall consist of testing 100% of the installed devices. This shall include initiating, notification, interface and control devices.
 - b. Initiating device testing shall not be performed using a magnet. Demonstration of the functionality of smoke detectors shall be performed using an UL listed aerosol product. Heat type spot detectors shall be tested using a UL listed heat source. Non-restorable heat detection devices shall not be tested.
 - c. Any failure of a device to function as required due to programming errors shall result in the test being immediately stopped. Testing will resume from the beginning after the programming error is resolved. Failure of a device to function due to a hardware failure will not require the test to restart from the beginning. The device shall be replaced and testing will resume where the test was temporarily halted.
 - d. Completed as-built drawings will be on site and verified during the acceptance test to include device addresses.
 - e. The Engineer of Record shall be present for the final acceptance testing.
 - f. After 100% of all notification devices are tested, one detection device in each zone shall be tested with the notification devices activated. Upon successful completion of that test, the remainder of the detection devices may be tested in a bypass mode.

4. References

Buildings requiring fire alarm systems as identified in the Chicago Building Code shall follow the established City permit process. Buildings which will have a fire alarm system installed even though it is a non-city required system, shall comply with the Chicago Building Code with regard to design and installation requirements.

The system and all components shall be listed by Underwriters Laboratory (UL) for fire protective signaling service under the latest edition of UL 864.

The system design and related components shall comply with the latest FM Global Property Loss Prevention Data Sheets and approved products as applicable.

O) ENERGY AND COMMISSIONING

Energy Conservation – Mechanical Requirements

1. All new mechanical systems shall be designed to conserve energy and shall conform to the University of Chicago’s Energy Policy Guidelines. Forms of energy recovery or conservation shall be investigated to maximize energy efficiency on each project.
2. Proposed systems shall meet or exceed the requirements set forth in the City of Chicago’s Energy Conservation Code.
3. Proposed systems shall have life cycle and energy cost analysis comparison. Base systems shall be a VAV Air Handling System as described in ASHRAE 90.1. Analysis shall be submitted to the University at the SD, DD and CD project phases.
4. All air conditioning systems shall have full economizer cycles.
5. Night set back schedules for space unoccupied times shall be incorporated into design.
6. Demand control ventilation shall be incorporated unless specifically demonstrated not to be feasible.
7. Design systems for spaces that need 24 hours per day operations separate from spaces that can utilize night set back. Example, data centers shall be design separate from the building HVAC system.
8. All incoming utilities shall be metered. Refer to Building Automation Standards for metering requirements.
9. Perform energy modeling at each phase of the design to include building activities and operation hours for use in setting up building utility budget.
10. Establish energy use benchmark such as btu/SF/year and compare with similar buildings on campus and elsewhere.

Commissioning Standard for Capital Projects

1. Program Overview:
The commissioning process is a quality-oriented process for achieving, verifying and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria. The fundamental benefits of the commissioning process are:
- Reduction of change orders and additional claims
 - Fewer project delays
 - Managed start-up requirements
 - Quicker and more effective building turn-over to operations
 - Less post-occupancy corrective work and vendor/contractor call backs
 - Minimized effects from design changes
 - Improved indoor air quality and reduction of occupant/client complaints
 - Better operation, maintenance and reliability
 - Lower energy and operational costs
 - Complete and useful system documentation and O&M manuals
 - Fully trained operations staff

Although the commissioning process requires an investment of time and money in the early stages of planning, a study conducted by the Lawrence Berkley Laboratories recently estimated the average payback period of commissioning new buildings to be 4.8 years. With the University owning and operating a majority of its buildings over 40 years, this offers a significant savings opportunity over time. In addition, commissioning can lessen the risks to critical operations and occupant safety and health by verifying proper installation and operations of systems such as emergency power, life safety systems, and elevators.

The commissioning process will be utilized on all university projects involving major mechanical, electrical or plumbing (MEP) work. For smaller projects the scope may be tailored to an individual project’s needs. The University Project Manager (PM) shall engage the University Commissioning Manger during the planning phase of a project to determine the adequate scope for commissioning for each project. The PM shall consult with the Capital Projects Director to determine if non-MEP portions of the work should be commissioned.

It is the goal of the University that projects with a construction value equal to or exceeding \$5 million will pursue LEED® Silver certification. This standard meets and exceeds the requirements established in LEED® NC v2009 EA prerequisite 1 “Fundamental Commissioning” as well as EA credit 3 “Enhanced Commissioning” and also incorporates many aspects of the BCA, ACG and ASHRAE guidelines.

R) ENERGY AND COMMISSIONING

The Building Systems and Equipment to be commissioned includes but is not limited to the following:

a. Mechanical Systems

- Heating, ventilating, and air conditioning systems, with all mechanical equipment forming a part of these systems (including, but not limited to piping, air handler units, fan coil units, exhaust fans, variable frequency drives, ductwork, etc.)
- Building chilled water systems, and all equipment forming a part of these systems (including, but not limited to piping, chillers, cooling towers, pumps, etc.)
- Heating hot water systems (including PRV stations, heat exchangers, pumps, etc.)
- Fuel pumping systems
- Smoke exhaust and evacuation systems
- Air curtains
- Geothermal systems
- Vertical transport
- Air compressors

b. Plumbing Systems

- Domestic water systems
- Natural gas systems
- Water treatment systems
- Landscape irrigation Systems
- Lab gas system
- Sump pumps and ejector pumps
- Thermostatic mixing valves (sampling may be deemed acceptable)
- Fixtures (sampling may be deemed acceptable)
- Acid neutralization

c. Electrical Power Systems

- Electrical supply and distribution systems including common and clean power systems.
- Main electrical gear systems
- Backup power systems
- Fire alarm systems
- Interfaces to automated temperature/building automation control systems
- Grounding systems
- Lighting control systems (including but not limited to occupancy sensors, daylight sensors and dimming controls.)
- Renewable energy systems including passive and active systems
- Access controls
- CCTV and security system

d. Life Safety Systems

- Life safety systems, and all equipment forming a part of these systems (This testing will be in addition to any code required safety verifications performed on qualified life safety system specialists.)

e. Building Automation, Controls and Metering

- Central building automation and controls systems, and all equipment forming a part of these systems (including, but not limited to linkages to remote monitoring and control sites, etc.)
- Instrumentation and sensors (with a sampling of operational range and calibration)
- Utility monitoring, meters and metering system.

2. Pre-design Phase

The following activities are to be conducted during the pre-design phase:

- a. Commissioning scoping and planning – during project programming the University PM should engage the University Commissioning Manager to participate in the process. At this point the Commissioning Manager will be the team’s liaison for commissioning requirements. The PM and Commissioning Manager will collectively determine the level of commissioning required for all projects involving MEP work and whether the commissioning authority (CxA) will be an internal resource or if an outside consultant will be hired. Factors such as project size and current workload will determine if commissioning activities can be handled internally. The Commissioning Manager should be consulted in the solicitation and selection of the Commissioning Consultant. The University Commissioning Manager can also assist in estimating commissioning costs for the project budget during the programming phase.
- b. Cx selection – Once the commissioning scope has been determined by the project manager and the University commissioning manager, the CxA can be brought on to the project. The University Commissioning Manager should be consulted to determine when involvement of the Cx will be most beneficial. The commissioning authority should be typically be brought on after the OPR is developed.

R) ENERGY AND COMMISSIONING

- c. Owner's Project Requirements (OPR) – The OPR is to be completed by the design team with input from the Owner and Commissioning Manager. The CxA shall conduct at least one review of the OPR. The OPR shall address the following issues at a minimum:
- Owner and user requirements – Describe the primary purpose, program and use of the proposed project and any pertinent project history. Provide any overachieving goals relative to the program needs, future expansion, flexibility, quality of materials, and construction and operational costs.
 - Environmental and sustainability goals – Describe any specific environmental or sustainability goals.
 - Energy Efficiency goals – Describe overall project efficiency goals relative to the local energy code, ASHRAE standard or LEED. Describe any goals or requirements for building orientation, landscaping, façade, fenestration, envelope and roof features that will affect energy use.
 - For each program or area, describe the intended use, anticipated occupancy schedules, space environmental requirements (including lighting, temperature, humidity, acoustics, air quality, and ventilation), desired adjustability of systems controls, and accommodations for after-hours.
 - Equipment and system expectations – Describe the desired level of quality, reliability, type, automation, flexibility and maintenance requirements for the building equipment. When known provide specific efficiency targets, desired technologies or preferred manufacturers for building systems.
 - Building occupant and O&M personnel requirements – Describe how the facility will be operated and by whom. Describe the desired level of training and orientation required for the building occupants to understand and use the building systems.

- d. Basis of Design (BOD). The Architect / Engineer (A/E) is responsible for drafting the basis of design. The BOD describes the building systems and outlines any design assumptions that are not otherwise included in the design documents. This document should be updated throughout the design and construction process. The BOD must have the following elements at a minimum:
- Primary Design Assumptions – Including space use, redundancy, diversity, climatic design conditions, space zoning, occupancy, operations, and space environmental requirements.
 - Standards – Include applicable codes, guidelines, regulations, and other references that will be put into practice.
 - Narrative descriptions - Include performance criteria for the HVAC&R systems, lighting systems, hot water systems, on-site power systems, and other systems to be commissioned.

3. Design Phase

The following activities are to be conducted during the design phase:

- a. The Cx shall conduct a review of the BOD prior to beginning of the design development phase. The review shall include the following elements:
 - BOD is thorough, complete and reflects the OPR.
 - BOD satisfies LEED® requirements (if applicable).
 - A review of the LEED® scorecard (if applicable) as it pertains to the equipment to be commissioned and any potential issues/ concerns.
- b. Design Review –Although the engineer of record is ultimately responsible for the design of building systems, the Cx shall perform an independent review of the plans and specifications. This design review shall exceed what is required by LEED® but will be less extensive than a full formal peer review. Particular attention should be paid attention to the performance, operation and maintenance of equipment. The Cx shall review the plans and specification for final DD's, and major CD milestones. The following issues at a minimum shall be considered while performing the design reviews:
 - Adequate access is given in order to perform Test and Balance as well as functional testing.
 - Access for equipment maintenance and replacement.
 - Equipment locations and capabilities vs. occupancy needs
 - Building Automation System (BAS) layout and system integration.
 - Complete and unambiguous sequence descriptions.
 - Sequences optimized for equipment performance and system efficiency.
 - Ability of achieving the owners project requirements and basis of design and coordination of commissioned systems.
 - Coordination between disciplines

R) ENERGY AND COMMISSIONING

c. Develop the Commissioning Specification – The Cx shall generate a commissioning specification for inclusion in the general conditions of the construction specifications no later than the 50% CD milestone. This specification shall be all encompassing for commissioning activities. It is the responsibility of the Cx to coordinate with the design team on other sections of the specifications that mention functional testing or commissioning- related activities so they are consistent with the formal commissioning sections. Care should be taken to cross reference between sections. The commissioning specification shall contain the following sections at a minimum:

- Commissioning team involvement
- Roles and responsibility
- A list of equipment and systems to be commissioned
- Incorporation of start-up and commissioning activities into construction schedule (list what need to be completed (system components, equipment, related systems and controls, etc) prior to starting commissioning of each system)
- Submittal review procedure
- Operations and Maintenance documentation requirements
- Project commissioning meeting overview
- Pre-functional checklist verification process
- Start-up plan development and implementation
- Issue log process
- TAB verification
- Functional performance testing requirements and process
- Acceptability and Closeout - Include how completion of commissioning activities relates to occupancy permits and project closeout.
- Training requirements
- Peak seasonal testing
- Warranty review
- System manual requirements
- Language assigning financial responsibility for failed tests to the appropriate parties.
- Include sample pre-functional checklist and functional test procedures.

d. Initial Commissioning Plan – The initial commissioning plan lays the groundwork for a successful commissioning process. The commissioning plan is intended to be a “living” document as details within the document will change as the project evolves. The initial commissioning plan should be submitted to the owner and design team for review prior to the 50% CD milestone. The initial commissioning plan should be drafted after the commissioning specification and include at a minimum the following elements:

- The scope of commissioning
- The commissioning team roles and responsibilities and lines of communication
- Reference documents
- Systems to be commissioned
- Commissioning meeting overview
- Sample pre-functional checklists (PFCs) – although the specific details for all equipment may not yet be determined, sample checklist for each type of equipment should be provided.
- Sample functional performance tests (FPTs) - although the specific details for all equipment may not yet be determined, sample checklist for each type of equipment should be provided.
- Commissioning schedule
- O&M documentation requirements
- Training requirements

e. Design Phase Acceptance – The Cx should sign off that all issues have been resolved at the conclusion of the design phase. The intent of this step is to verify that all commissioning related concerns have been addressed prior to initiating the bid phase. In the event that the Cx and the EOR are not in agreement about a particular issue the University will work with all parties to resolve any differences of opinion.

4. Construction Phase

The following activities are to be conducted during the construction phase:

- a. Commissioning meetings – Open communication between the commissioning team is integral to a successful project. Commissioning meetings are not meant to burden the team members but rather to proactively discuss ongoing issues and potential concerns. The frequency and length of meetings should be sufficient enough to facilitate a commissioning process that is seamless with construction. The following commissioning meetings should be conducted during the construction phase:
- Commissioning kick-off meeting - The Cx shall conduct a kick-off meeting to review the commissioning process with the commissioning team. Attendees required at the kick-off meeting include the architect, engineer, construction manager/ general contractor, and all appropriate sub-contractors (including the TAB contractor). The Cx shall prepare the meeting agenda and issue meeting minutes.
- Construction meetings - The Cx should participate regularly in construction meetings. The expectation is that the Cx will attend sufficient meetings in order to be well informed of project status and developments. The Cx should also attend all pre-bid meetings associated with portions of the work to be commissioned .
- Commissioning meetings – The Cx should conduct regular commissioning meetings with the construction team. These meetings may not be regular during the initial phases of construction but as the project progresses the meetings shall be held more regularly. The frequency of these meetings should be agreed upon by the University and Cx. The Cx shall prepare the meeting agenda and issue minutes. Meeting minutes shall be prepared and distributed to all meeting participants within 48 hours of the meeting.

R) ENERGY AND COMMISSIONING

- Controls integration meeting –the Cx should facilitate a controls integration meeting. A controls integration meeting between the Cx, the designers, the controls contractor, and the building operator is held after the controls submittal review and prior to submittal approval. The goal of this meeting is to facilitate resolution of review comments, and verify that the control system and system sequences are complete, verifiable, coordinated and meet the OPR.
- b. Construction submittal reviews – The Cx shall review all construction submittals for the systems to be commissioned. Commissioning review of the submittals should be conducted concurrently with the design team. All review comments should be submitted to the architect/engineer for incorporation. The architect/engineer has the final authority to accept or reject the submittals. The Cx should specifically evaluate the submittals for the following:
 - Conformance with the owner project requirements and basis of design.
 - Acceptability of factory testing and pump/fan curves
 - Fulfilling operation and maintenance requirements.
 - Facilitating TAB and performance testing.
 - Optimization of efficient equipment and systems
- c. Update commissioning plan – The initial commissioning plan should be updated with the project design details after the 100% CDs are released. A master list of commissioned equipment shall be created. Pre-functional checklist (PFC) as well as functional performance tests (FPTs) should be completed utilizing the approved construction submittals and installation manuals to make the checklists specific to the installed equipment. The commissioning plan shall be updated throughout the construction phase to reflect any changes due to submittals, RFIs, ASIs, etc. PFCs and FPTs shall be project specific. Generic “canned” forms are not acceptable. Generally, 100% of equipment shall be tested. In the case that 100% testing is not feasible or financially prudent, sampling plans should be pre-approved by the University Commissioning Manager.
- d. Commissioning Status Reports – The Cx shall issue a commissioning status report monthly. The report should compile a list of deliverables and current status of each item.
- e. Integration of commissioning activities in the construction schedule – The Cx shall work with the general contractor/ construction manager to incorporate the various start-up and commissioning activities into the project schedule. Ample time should be given to perform TAB and functional testing in the schedule. Functional testing should be tied to its pre-requisites such as system start-up, TAB and point to point testing. Construction schedule and commissioning schedule shall be integrated with all detailed tasks and activities shown in a sequential manner. This will provide realistic intermediate milestone dates. Project scheduler shall update the scheduled dates and actual dates bi-weekly and distribute to everyone in the construction team.
- f. Site visits – The Cx shall verify the contractor progress of pre-functional checklists. Equipment, systems and assemblies in the commissioning scope should be examined. The PFCs should be audited during each site visit to assure that contractors are completing the PFCs correctly and in a timely manner. PFCs shall be updated by the contractors routinely as the project progresses, not all at the end of a project. Only contractors having direct knowledge of the activity should sign off on each line item. The Cx should submit a site visit report to the University within no later than the following working day and identify any concerns or deficiencies. When possible a digital photo should be taken of any deficiencies or observations and included in the report. The University prefers that construction phase communications are automated and timely. The use of software tools during the construction phase (i.e. Vela, Latista, or proprietary systems) increase the project team’s ability to automate the deficiency resolution process. Although this technology is not required by the University at this time it has been deemed advantageous on large projects. The use of such software tools will be considered when evaluating qualifications of providers.
- g. System start-up – The general contractor/construction manager shall submit a start-up plan (including vendor/ contractor start-up procedures and forms) to the Cx for review. A minimum two week notice should be provided to the Cx and the University for participation in system start-up and/or testing if the dates differ from those included in the construction schedule. Valves should not be opened, motors bumped or equipment energized prior to having the proper documentation submitted and appropriate people present. This is crucial so that the process is handled safely, activities are properly documented and warranties are appropriately kept. The Cx should attend an adequate number of start-ups in order to confirm proper procedures and documentation are followed. All completed start-up forms should be submitted to the Cx for review and become part of the final commissioning report. Start-up testing includes flushing, pressure testing as well as official equipment start- up.

R) ENERGY AND COMMISSIONING

- h. Maintain and distribute a commissioning deficiency list
 - The commissioning authority shall maintain a log of all project issues encountered during the commissioning process. While the commissioning authority may not have the ability to correct the issues, it is expected that they work closely with the general contractor / construction manager and design team to resolve any issues. A proactive and collaborative process of addressing project issues as they arise is a vital part of a successful project. The University expects the Cx to exercise a great deal of leadership and perseverance in assisting the project team in resolving issues.
- i. Test and Balance (TAB) – The TAB contractor shall submit a test and balance plan to the Cx for review by the Cx prior to performing any TAB activities. TAB plans should contain the forms to be used during TAB. Only instruments calibrated within the last 12 months to an NIST traceable standard should be used during TAB. The TAB contractor shall submit calibration sheets to the Cx for all equipment to be used prior to starting TAB. The TAB contractor shall under the supervision of the Cx, repeat a portion (generally 10%) of the TAB readings sufficient enough to prove readings are repeatable. The Cx shall review the final TAB report (the completed field report is acceptable) prior to conducting functional performance testing.
- j. System readiness –The following activities shall be complete before functional testing: installation and PFCs (including end to end testing) complete, TAB complete and report reviewed. The general contractor / construction manager shall notify the University and the CxA in writing that functional testing requirements are met and system(s) are ready for functional testing.

5. Acceptance Phase

- a. Functional Testing – The CxA shall direct, witness and document the results of the functional performance testing of all systems to be commissioned. Each functional test should have specific acceptance criteria on which the results will be evaluated. The construction schedule should be used to schedule functional testing and resources needed for testing. The general contractor / construction manager is responsible, with input from the CxA, for coordinating participation by the appropriate sub-contractors and vendors. The CxA should also notify the general contractor / construction manager in advance if special testing equipment is needed. Operations personnel from the University are encouraged to attend functional testing. Immediately after test and balance, trending should be performed and included in the commissioning report as additional documentation supporting the proper operations of the systems. Instrumentation should be verified to be accurate in the field, at the local controls and at the campus BAS. Any meter for campus utilities including (but not limited to steam, chilled water, and condensate) should be verified to be operational in the field, at the Ion system as well as the campus BAS. Meters should be checked at high flow, no flow and typical operating conditions. During functional testing graphics on the campus BAS should be verified. Any testing conducted at the local control level should be pre-approved by the University. System setpoints should always be recorded prior to initiating testing and returned to their pre-testing values at the conclusion of testing. Documentation that this procedure is followed should be part of FPTs. During testing it is acceptable to override setpoints or process variables in order to simulate conditions. However, it is important to document the method of each test conducted in order to provide a level of repeatability to testing. If problems or incomplete work are discovered during functional performance tests, the responsible contractors must correct or complete the work and have it re-tested with satisfactory results before proceeding to the next stage of commissioning. If numerous problems indicate that the installation is not ready for FPTs, the commissioning authority should halt testing and immediately notify the general contractor / construction manager and University.

- Excessive retesting costs (more than 10% repeat) will be charged to the responsible contractor not to the University.
- b. Operations and Maintenance Manual review – The CxA shall review all O&M manual for equipment in the commissioning scope. The CxA shall receive a copy of each O&M document in its final form no later than 50% completion of construction. Partial or draft submissions will not be acceptable. The CxA will perform their commissioning review concurrently with the EOR. Comments will then be forwarded to the EOR for incorporation. O&M documents shall be finalized utilized during the training process.
- c. Training Review – The CxA will verify that all training requirements have been met. The general contractor/ construction manager shall submit a training plan complete with an agenda for each session to the CxA no later than 50% completion of construction or 60 days prior to scheduling training activities whichever comes first. The CxA will attend a sufficient amount of training sessions enough to be confident that contractual requirements have been met. The CxA will review all training documentation including sign-in sheets and video (if applicable) to ensure all requirements have been met.

R) ENERGY AND COMMISSIONING

- d. Systems Manual – The Cx will assemble and distribute a systems manual for the project prior to training. Final versions of some documents may need to be updated after training. Although the Cx is not responsible for generating all the documents within the systems manual, they are responsible for attaining the documentation and collating it. The systems manual shall contain the following documents however the parties noted in parenthesis are responsible for providing:
- Final Version of the BOD (A/E)
 - System single-line diagrams (A/E)
 - As-built sequences of operations, control drawings, and original setpoints (Controls Contractor)
 - Operating instructions for integrated building systems (sub-contractors)
 - Recommended schedule of maintenance requirements and frequency, if not already included in the project O&M manuals. (sub-contractors)
 - Recommended schedule for retesting of commissioned systems with blank test forms from the original commissioning plan. (Cx)
 - Recommended schedule for calibrating sensors and actuators. (CC)

- e. Final Report – The Cx shall issue a final report within 30 days of functional testing. The final report shall include the following at a minimum:
- Executive summary of the process and the results of the commissioning program by equipment and systems, including observations, conclusions and any outstanding items.
 - Deficiency list complete with closed items and any open items clearly identified with resolution recommendations and a cost benefit analysis.
 - Functional test results.
 - Confirmation from the Cx indicating whether individual equipment and systems meet the owner’s project requirements, basis of design, and contract documents.
 - Summary of the design review process
 - Summary of the submittal review process.
 - Summary of the O&M documentation and training process.
- f. Peak Season Testing – The Cx shall conduct peak season testing during the first summer and winter seasons after occupancy. Peak season testing is not intended to be a complete repeat of functional performance testing but rather a repeat of the systems whose performance is greatly dependent on the conditions outside. (i.e chillers in summer and boilers in winter). During peak season testing trending should also be set-up and reviewed to verify that HVAC zones are able to operate as designed.
- g. Warranty Review – The Cx shall conduct a warranty review 10 months after substantial completion. The Cx should coordinate with the University a walk-through, and interview building operators and occupants. The Cx shall submit any suggestions to optimize operations in their warranty report. Any ongoing issues should be investigated and if necessary systems retested. A warranty review report should be issued 7 days after the visit and be an addendum to the commissioning final report.

References

ACG Commissioning Guideline 2005
ASHRAE Guideline 0-2005 - The Commissioning Process
New Construction Building Commissioning Best Practice - Building Commissioning Association, December 8, 2011
THE COST-EFFECTIVENESS OF COMMERCIAL-BUILDINGS COMMISSIONING A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States Lawrence Berkley Laboratories December 15, 2004
LEED Reference Guide for Green Building Design and Verification, 2009 Edition

V) INDOOR AIR QUALITY (IAQ)

1. Introduction

This portion of the Facility Standards includes Indoor Air Quality (IAQ) guidelines to be followed by the Consultant during a project at the University of Chicago.

These recommendations are intended to support IAQ best practices post-Covid, and be used as part of the University’s emergency response. Based on research of peer institutions and industry best practices, with input from UC Facilities Services, the recommendations are framed in a way to A) maintain consistency between the small project guidelines and the FS2, B) balance capital and maintenance costs in the context of added value vs. perceived risk, C) provide flexibility in operations, and D) support campus energy reduction goals.

2. Related Sections

Related sections of these standards include:

Vol III: General Design Requirements

C - Sustainability

I – Interior Finishes and Accessories

K – Mechanical Systems

L – Building Automation Systems

3. Indoor Air Quality (IAQ):

Vol III C - Sustainability

- 3. Guidelines, c) Energy, Goals: Improve indoor air quality through a holistic mechanical design approach, in which it is designed relative to other design goals such as energy use, carbon footprint, comfort, etc.
- 3. Guidelines, c) Energy, Strategies, Maximize Mechanical System Performance: Install occupancy control and automation programming/control sequences that enable pandemic mode settings for mechanical system operations. These controls will also facilitate MBCx.
- 3. Guidelines, c) Energy, Strategies, Maximize Mechanical System Performance: Design systems to accommodate MERV 8 prefilters and MERV 13 filters with space to accommodate future installation of air sanitization systems like BPI or UV where practical.

- 3. Guidelines, e) Health, Comfort and Productivity, Strategies, Provide Healthy Ventilation: Design mechanical systems to accommodate additional fresh air (up to 30%) and modulate accordingly. Consider DOAS with heat recovery.
- 3. Guidelines, e) Health, Comfort and Productivity, Strategies, Provide Healthy Ventilation: Conduct a building flush-out of 14,000 cubic feet of outside air per square foot that follows LEED guidance, where possible.
- 3. Guidelines, e) Health, Comfort and Productivity, Use Low Volatile Organic Compounds-emitting Materials: Ensure that all construction materials, interior finishes, and major furnishings installed at the University comply with the most recent LEED standard for VOC content and Emissions Evaluation, including interior paints and coatings applied on site, interior adhesives and sealants applied on site, flooring, composite wood, ceilings, walls, thermal and acoustic insulation, and furniture.
- 3. Guidelines, f) Education and Training, Physical Infrastructure Enables Education: Consider the installation of RESET Accredited continuous air quality monitors.

Vol III I – Interior Finishes and Accessories

- I-2 – Interior Finishes Matrix

Vol III K - Mechanical Systems

- 5. System Design Requirements, D. Install occupancy control and automation programming/control sequences that enable pandemic mode settings for mechanical system operations. These controls will also facilitate MBCx
- 5. System Design Requirements, K. The system should be capable of providing additional fresh air and modulate accordingly.
- 5. System Design Requirements, P. Design for system resilience and adaptability that may include the ability to accommodate MERV 8 prefilters and MERV 13 filters. Consider HEPA filtration in critical spaces.

- 7. Campus Utility System Requirements, A. Air Handling Systems, v. Custom Indoor Air Handling Units, a. Unit Casings & Base, Allow space to accommodate the future installations of BPE or UV air sanitization systems.

Vol III L – Building Automation Systems (In addition to these changes, the entire section is currently being revised)

- 2. System Guidelines, b) Equipment, 12. Auxiliary Control Devices, a. General, i., 17. Continuous Indoor Air Quality Monitors (PM, CO2, TVOC, RH, Temp, etc.)
- 2. System Guidelines, r) Continuous Air Quality Monitors, Continuous Air Quality Monitors, if installed, should be RESET accredited. These sensors should not control building systems, but be connected to the BAS for data collection, storage, and analysis.