



# **INSTITUTE DESIGN GUIDE**



**JUNE  
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# 1 INTRODUCTION

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## 1.1 PURPOSE OF THE INSTITUTE DESIGN GUIDE

### 1.1.1 Purpose

VMI is dedicated to providing high quality facilities that enhance the learning experience for our cadets and provide the environment that supports an excellent education in a structured military environment. VMI has been training cadets since 1839, and the historical nature of the post is an integral part of the VMI experience. Our buildings and grounds are rich in history; construction of new facilities and modifications to historic buildings and site elements must maintain a cohesiveness with the look and feel of the surrounding facilities.

In addition to VMI's commitment to preserving the historic nature of post and our other historic properties, we are also dedicated to using thoroughly modern building construction methods and building systems to provide lasting, efficient, and sustainable environments for cadets, faculty, staff, and visitors to VMI. It is important that our construction projects integrate long-lasting, high-quality elements that provide good service and efficient operations over a long facility life.

This Guide contains information that will assist design firms in understanding VMI's preferences, best practices, processes, and philosophy as related to the design of new building, grounds, and utility projects on VMI properties. Design firms should become thoroughly familiar with this Guide as they begin to work with VMI to help them provide a high-quality product in a cooperative relationship with VMI stakeholders.

### 1.1.2 Scope

The VMI Institute Design Guide is a reference for Architects, Engineers, and Landscape Architects engaged in the design of new facilities, modifications to existing facilities, site improvements, and infrastructure projects on properties under the control of Virginia Military Institute. The Guide covers procedural and technical requirements pertaining to the process of project design from inception through construction phase. This Guide does not specifically address construction standards or procedures pertaining to the activities of construction contractors.

This Guide, in conjunction with all applicable codes and standards (including the Construction and Professional Services Manual – CPSM), is to be used in all design projects on the VMI post and other VMI properties unless certain portions are specifically waived or modified by VMI. It is intended that the Design firm use this Guide in collaboration with VMI stakeholders to provide designs that are aligned with best practices developed for VMI projects as well as all applicable codes and standards.

### 1.1.3 Applicability

This Guide applies to all projects executed on properties under the control of Virginia Military Institute. Projects under the purview of this Guide may be funded using various sources including State, VMI, grant or other fund types.

## 1.2 WHY A POST AND NOT A CAMPUS?

The Mission and Vision of VMI clearly illustrate the differences in philosophy and the commitment to the total and well-rounded cadet that make VMI a unique learning environment.

### 1.2.1 Mission and Vision

#### **Mission**

*Virginia Military Institute believes that the measure of a college lies in the quality and performance of its graduates and their contributions to society.*

*Therefore, it is the mission of Virginia Military Institute to produce educated, honorable men and women, prepared for the varied work of civil life, imbued with love of learning, confident in the functions and attitudes of leadership, possessing a high sense of public service, advocates of the American Democracy and free enterprise system, and ready as citizen-soldiers to defend their country in time of national peril.*

*To accomplish this result, Virginia Military Institute shall provide to qualified young men and women undergraduate education of highest quality -- embracing engineering, science, and the arts -- conducted in, and facilitated by, the unique VMI system of military discipline.*

#### **Vision**

*To be the premier small college in the Nation, unequalled in producing educated and honorable citizen-leaders, with an international reputation for academic excellence supported by a unique commitment to character development, self-discipline and physical challenge, conducted in a military environment.*

### 1.2.2 Rationale for a Military Environment

Though the cadets at VMI are college students first - part of the student body of a Commonwealth institution of higher education; the military aspects of VMI's cadet training and daily life contribute greatly to the development of high-quality graduates who represent the ideals framed by the Mission and Vision of the Institute. A military environment is central to the development of these graduates and citizen-soldiers who represent the ideals of VMI.

In providing the discipline and training benefits of a military environment, it is important that the buildings and grounds support the structure and regimented activities of a military type program. Where most colleges and universities have dormitories, quads, and recreational fields, VMI has barracks and a Parade Ground. These distinctions maintain the military bearing that supports the mission.

It is important that design firms working on VMI understand these distinctions, and be always cognizant of what distinguishes VMI from other Commonwealth institutions. These unique features are integral to providing the VMI experience and to developing the character and values that distinguish VMI cadet graduates. U.S. Army installations are referred to as "posts", and in recognition of the military characteristics that make VMI unique, the buildings and grounds comprising VMI in Lexington are always referred to as "post", not "campus".

## 1.3 CONTACTS

### 1.3.1 Institute Planning Office

Dr. Gus Singleton Jr. – Institute Planning Officer

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### 1.3.2 Facilities Management

Keith Jarvis – Director of Facilities Management

[jarvstk@vmi.edu](mailto:jarvstk@vmi.edu)

### 1.3.3 Physical Plant

Eric Schwartz – Deputy Director of Facilities Management  
For Physical Plant and Facilities (P2)

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### 1.3.4 Museum Programs (Includes Historical Preservation)

Col. Keith Gibson – Director of Museum Programs

[gibsonke@vmi.edu](mailto:gibsonke@vmi.edu)

### 1.3.5 Construction Office

Lt. Col. Daren Payne – Deputy Director of Facilities Management  
Construction and Engineering

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### 1.3.6 Information Technology

Darren Campbell – Director

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## 1.4 RESOURCES

### 1.4.1 CPSM (Virginia Construction and Professional Services Manual)

The CPSM shall be used as a reference in all projects at VMI and will be applied either completely or selectively depending upon the scope, size, and funding source for the project. The VMI project Point of Contact will inform the Design firm of specific CPSM applicability. The latest CPSM version in effect at the time of Preliminary Design approval shall govern the project through its life cycle. The Department of Engineering and Buildings (DEB - a division of Virginia DGS) is the authority that supports and enforces the requirements of the CPSM. The latest version of the CPSM can be located here:

<https://dgs.virginia.gov/engineering-and-buildings/statewide-constructionproject-management/current-cpsm-edition/>

### 1.4.2 Virginia Public Procurement Act

This law governs procurement by State agencies including colleges and universities and can be referenced here:

<https://law.lis.virginia.gov/vacodepopularnames/virginia-public-procurement-act/>

### 1.4.3 VMI Procurement Policies

These can be found in Section 90000 of the “VMI Accounting Policies and Procedures” manual – *Purchasing Policies and Procedures*.

#### 1.4.4 Codes

##### 1.4.4.1 *Virginia Uniform Statewide Building Code (VUSBC)*

- Part I – The Virginia Construction Code – Regulations specific to the construction of new buildings and additions
- Part II – The Virginia Existing Building Code – Regulations specific to the rehabilitation of existing buildings and changes in occupancy
- Part III – The Virginia Maintenance Code – This section is not applicable to construction and renovation projects at VMI

The latest VUSBC version in effect at the time of Preliminary Design approval shall govern the project through its life cycle. If preliminary designs are approved within 4 months of the adoption of a new VUSBC, VMI officials may choose to have the project designed per the new Code version.

##### 1.4.4.2 *NFPA Code Series*

The following codes and regulations are incorporated into the latest adopted version of the VUSBC and are applicable to projects on VMI sites. The current VUSBC indicates the year of each code incorporated.

- NFPA 70 – National Electrical Code
- NFPA 13 – Standard for the Installation of Sprinkler Systems
- NFPA 72 – National Fire Alarm Code
- NFPA 101 – Life Safety Code

##### 1.4.4.3 *Other Applicable Federal and State Codes*

The latest adopted version of each of the following codes and regulations is applicable to projects on VMI sites.

- Title II, Americans with Disabilities Act of 1990
- Occupational Safety and Health (OSH) Act of 1970
- Virginia Occupational Safety and Health (VOSH) Program
- Virginia Statewide Fire Protection Code (SFPC)
- Virginia Industrialized Building Safety Regulations (IBSR)
- Virginia Public Building Safety Regulations
- Virginia Fire Safety Regulations
- Virginia Department of Environmental Quality (DEQ) – Erosion and Sediment Control Regulations
- Virginia Department of Environmental Quality – Stormwater Management Regulations
- Virginia Department of Health (VDH) Regulations
- Virginia Water Works Regulations (Virginia Department of Health)
- Virginia Sewage Collection and Treatment (SCAT) Regulations (Virginia Department of Environmental Quality)

##### 1.4.4.4 *Hazardous Materials Codes*

There are times that VMI is a Very Small Quantity Generator of hazardous wastes. Some applications include disposal of lead from the indoor and outdoor firing ranges, larger asbestos abatements, and larger lead-based paint abatements. Regulations for this activity are:

- Very Small Quantity Generator Regulations
  - VSQG Definition - 40 CFR § 260.10
  - VSQG Mixtures - 40 CFR § 262.13(f)
  - Conditions for Exemption for a VSQG - 40 CFR § 262.14
  - Landfill Ban for Liquids - 40 CFR § 262.14(b)
  - Episodic Generation - 40 CFR Part 262 Subpart L
- Asbestos-Containing Materials
  - Virginia Code: Duties of licensed asbestos and certified lead contractors - § 40.1-51.20
  - Virginia Code: Asbestos NESHAP Act - § 40.1-51.23
- Lead-Based Paint Regulations
  - Virginia Administrative Code – 18VAC15-30 – Virginia Lead-Based Paint Activities Regulations

#### ***1.4.4.5 Reactivated Projects***

Prior to restarting a project that has been on hold for an extended period, VMI and/or DEB officials will review any code changes that have occurred in the interim period and determine if a newer Code applies to the project going forward.

#### ***1.4.4.6 Modifications to Code Requirements***

If the A/E believes that a modification to the VUSBC is necessary to accommodate the requirements of the project, the A/E needs to request such modifications in writing with the Preliminary design submittal. The written request should clearly state the nature of the conflict with the VUSBC and the rationale for requesting a change or waiver of requirements. The Authority Having Jurisdiction (typically DEB) will review the request and determine if the requested modification will be granted or denied using a Determination and Findings Report (D&F) for Code Modifications.

## 2 GENERAL REQUIREMENTS

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### 2.1 PROJECT DELIVERY METHODS

#### 2.1.1 Definitions of Capital vs. Non-Capital Projects

The Virginia Construction and Professional Services Manual generally defines Capital Projects as projects with a total value of \$3,000,000 or greater. Projects with a total value of less than \$3,000,000 are defined as Non-Capital projects. In general, non-capital projects costing more than \$15,000 and requiring more than three days to execute are assigned to the Construction Office and non-capital projects costing \$15,000 or less and taking 3 days or less to execute are managed by the Physical Plant. However, this is a general guide, and the Director of Facilities Management may make exceptions.

#### 2.1.2 Construction Delivery Models

VMI has the option to use one of three construction delivery models:

- Design / Bid / Build (DBB)
- Construction Manager at Risk (CMAR)
- Design-Build

Each of these models has unique characteristics that require different actions by the designer.

##### 2.1.2.1 *Design / Bid / Build (DBB)*

This is the typical model for smaller or less complex projects. In this model, the A/E prepares a full design package incorporating plans and specifications which is 100% completed at the time of advertisement and bidding. VMI may use an open procurement, on-demand contractors, or pool contractors when selecting prospective construction bidders depending upon project type and size.

##### 2.1.2.2 *Construction Manager at Risk (CMAR)*

In this model, VMI firsts seeks approval from DEB to use the CMAR procurement method and then qualifies and secures a contract with the CMAR prior to the completion of Schematic Design documents. The A/E and the construction firm are both contracted directly to VMI but are positioned to collaborate in the development of the design and the eventual Guaranteed Maximum Price (GMP). This model is often used to deliver larger and more complex construction projects on post.

##### 2.1.2.3 *Design-Build*

This model employs a commercial team comprising a construction contractor and a design firm who work together to develop, and then execute, the project design and construction. This type of delivery requires a three-step procurement process as follows:

- Development of Project Requirements – The Institute will work with a design firm or internal stakeholders to develop a design-build bid package and solicitation, sometimes referred to as “bridging documents”. This package will include concept designs for the project, descriptive narratives describing the work to be done, and other supporting technical and commercial materials. Design is often carried through approximately 15% completion in most bridging document packages to allow the design-build team to fully understand requirements and prepare pricing proposals.



- Qualification of Design Build Teams – Typically, the bridging documents are advertised and design-build teams prepare statements of qualifications (SOQ) in response to the solicitation. The SOQ typically illustrates the experience of the firms and key staff, past project experience and performance history, and approach to executing the project. From SOQ submittals, VMI will select a short list of firms to move on to the next phase of the D-B competition.
- Selection of Final D-B Team by Proposal – In this phase, the D-B teams prepare specific proposals to execute the projects including expanded design team information, detailed approach, partial plans and details as needed to demonstrate concept, construction schedules, and binding cost estimates for total design and construction costs. VMI then selects one team to move forward and contracts the Design-Build entity under a single Design-Build contract.

### 2.1.3 Use of On-Demand Contractors

#### 2.1.3.1 *On-Demand Construction Contract – ODCC*

VMI maintains a group of pre-approved general contractors selected through a competitive RFP process who can execute projects ranging from \$15K - \$500K in construction value. These projects are typically Non-Capital, and in most cases are professionally designed projects with construction plans and specifications, though replacement projects may also be contracted in this manner. The contract is procured through VASCUPP (Virginia Association of State College & University Purchasing Professionals) and, as such, is accessible by other public bodies and public or private health or educational institutions. This contract is a one-year contract with four optional renewal years. The latest contract was established in 2019.

When VMI desires to use the ODCC contract, an informal request for written bids is sent to all approved ODCC GC's in the contract. VMI then selects the contractor with the lowest pricing from the bids received.

#### 2.1.3.2 *On-Demand Trades Pool Contract*

VMI maintains a group of pre-approved single-trade contractors selected through a competitive RFP process who can execute projects ranging from \$5K - \$50K in construction value. These projects are Non-Capital, and are not typically professionally designed projects with construction plans and specifications. The contract is also procured through VASCUPP (Virginia Association of State College & University Purchasing Professionals) and is accessible through the same means as the ODCC contract. This contract is a one-year contract with four optional renewal years. The latest contract was established in 2019.

When VMI desires to use the ODCC contract, an informal request for written bids is sent to all qualified trades contractors in the contract. Only contractors with the capability to execute the specific trade in-house are solicited to bid. VMI then selects the contractor with the lowest pricing from the bids received.

## 2.2 APPLICABILITY OF THE CPSM

### 2.2.1 Capital Projects

Capital projects adhere totally to the requirements in the CPSM, including all DGS forms.

### 2.2.2 Non-Capital Projects

Non-Capital, Annual Permit projects may use VMI specific forms and procedures. A specific example of a process that differs from Capital projects is the DGS change order process. Non-Capital projects may process change orders using VMI specific documentation unless they are bond funded, in which case DGS change order forms apply. Non-capital projects that require changes or additions to life/safety or egress components may require use of DEB forms and DEB review.

## 2.3 VMI PROJECT FLOW

### 2.3.1 Project Initiation

Design services may be initiated by one of four methods:

- By Open solicitation – Design projects may be openly advertised via public Requests for Qualifications. In these cases, VMI will accept Statements of Qualifications from interested design firms, and will typically select a “short list” of qualified firms from the pool of applicants. When using a short list selection method, the Institute will conduct interviews with a sub-group of proposers and select a firm to negotiate with to enter into a design contract. This model is used to select design firms for larger capital projects or to select a panel of qualified firms to enter into Term Agreements. VMI reserves the right to select a firm to negotiate with without the interview process.
- By Task Order to an existing Term Contract holder – In the model, VMI issues a Request for Proposal to a Term Contract holder. The design firm submits a scope and fee proposal using DGS form CO-2.3. VMI then accepts the design firm’s proposal or negotiates fee and or scope to arrive at an acceptable task order assignment.
- By competitive RFP to existing Term Contract holders – In this case, VMI may ask two or more existing Term Agreement firms to submit proposals against a scope of work. VMI will then select a firm for the task order based on the qualifications, understanding, and approach included in the proposal and will negotiate the task order fees with the selected consultant.
- As a part of a design/build process – In this case, a team consisting of a constructor and a design firm will compete to be awarded a design/build project as described in Section 2.1.5.3.

### 2.3.2 Project Organization

Following project initiation as described above, the Deputy Director of Facilities Management from Engineering and Construction will assign a point of contact (POC) for each project. The POC will serve as the VMI project manager and will direct the design effort for the Institute. In most cases, projects are organized as follows:

- Capital Outlay and Non-Capital projects are managed by the Construction Office
- Planning projects (master planning, preliminary studies, other high level planning and budgeting efforts at an Institute level) are generally managed by the Institute Planning Office
- Maintenance Reserve projects are managed by with a value greater than \$15,000 and a duration greater than three days are managed by the Construction Office.
- All projects with a value less than \$15,000 and three days or less in duration are managed by the Physical Plant.

The Design Firm's project manager (PM) will interface directly with the VMI POC on issues dealing with scope, schedule, and budget.

Jointly, the VMI POC and the Design Firm PM will establish other formal or informal relationships within the project team to handle logistical and technical issues during design. It is common for members of the design team to interface directly with members of the VMI technical or administrative functions to work out technical details and logistics of the project design and deliverables.

Communications that affect the design, the scope, the schedule, or the budget are always copied to the VMI PM and the Design Firm PM, regardless of who is communicating.

Regular progress meetings will be established by the VMI POC and the Design Firm PM. These may be more or less formal, depending upon size and complexity of the project. The Design firm is responsible for documenting and distributing meeting minutes.

Projects following the CPSM submittal format (Schematic, Preliminary, and Working Drawings submittals to the Department of Engineering and Buildings - DEB) will submit concurrently to VMI and to DEB for review and comment Submittals to DEB will be made via Electronic Document Review (EDR) processes.

VMI has the option to retain the Design Firm to provide Bid and Construction Phase services as outlined in section 2.3.3 below. In this case, the Design Firm will be responsible for activities supporting the award of the project and subsequent construction activities. VMI may request a scope and fee proposal for these services either as a part of the design services proposal or as a separate task after the start of design.

### 2.3.3 Project Activities / Services Required

The following checklist contains the majority of the services that may be included in the A/E firm's scope. The RFP from VMI should indicate which of these services will be included in the project scope, however this checklist should be reviewed with the VMI POC at the initiation of each project to clarify the activities and deliverables required of the A/E.

Project Phase	Activity or Service	Required	Not Required
Initiation	Kickoff Meeting		
Initiation	Pre-Design Conference		
Schematic	Basis of Design Narrative		
Schematic	CR-2 Form		
Schematic	Schematic Drawings		
Schematic	Schematic Cost Estimate		
Preliminary	Preliminary Drawings		
Preliminary	Preliminary Specifications		
Preliminary	A/E Preliminary Cost Estimate		
Preliminary	Independent Prelim. Cost Estimate		
Preliminary	Preliminary Calculations		
Preliminary	CR-2 Form		
Preliminary	VE Study		
Preliminary	Geotechnical Report		

Preliminary	Site Survey		
Working Dwgs.	Working Drawings		
Working Dwgs.	Working Specifications		
Working Dwgs.	Working Drawing Cost Estimate		
Working Dwgs.	VE Study		
Working Dwgs.	Final Calculations		
Working Dwgs.	Permit Drawings / Submittals		
Bid	Instructions to Bidders and Bid Forms		
Bid	Contractor Pre-Qualification		
Bid	Advertising for Bids		
Bid	Pre-Bid Meeting		
Bid	Bid Review and Tabulation		
Construction	Pre-Construction Meeting		
Construction	Submittal Review		
Construction	RFI Management		
Construction	Change Order Management		
Construction	Pay Application Review		
Construction	Construction Observation		
Construction	Construction Progress Meetings		
Proj. Close Out	Substantial Completion Inspections		
Proj. Close Out	Final Completion Inspections		
Proj. Close Out	Punch List Management		
Proj. Close Out	Commissioning Participation		
Proj. Close Out	O&M Manual Development or Review		
Proj. Close Out	As-Built Drawing Preparation		

## 2.4 GENERAL DESIGN PACKAGE REQUIREMENTS

### 2.4.1 Applicability of the CPSM

The CPSM will be the guide for the contents and format of the design package at each submittal phase. For purposes of this guide, the 2024 version of the CPSM is used as a reference.

The CPSM is available at this link:

<https://dgs.virginia.gov/engineering-and-buildings/statewide-constructionproject-management/current-cpsm-edition/>

### 2.4.2 Format and Contents of Drawings

Design documents shall follow the requirements of Section 5.2 – “General Requirements for Drawings” of the applicable version of the CPSM.

### 2.4.3 Specific Safety Requirements to Include in Specifications

#### 2.4.3.1 Safety Regulation Compliance

Include within Specification Section 01 73 00 – EXECUTION - language requiring compliance with all applicable State, Local, and Federal safety regulations, explicitly citing OSHA compliance.

#### **2.4.3.2 Hot Work Permits**

Include within Specification Section 01 73 00 – EXECUTION - language requiring the Contractor to maintain its own Hot Work Permit procedures, and add requirements that the Contractor shall prepare Hot Work Permits as required during construction, maintain them on the jobsite, and submit them to VMI staff as requested.

#### **2.4.4 Submittal Package Contents**

At each required submittal (Schematic, Preliminary, Working) A/E is to submit all applicable documents produced through the activities in Section 2.3.3 above per the “Submittal Requirements” in the CPSM, applicable edition, Sections 5.6, 5.7, and 5.8.

#### **2.4.5 Review Submittals to DEB**

Design work to be approved by DEB can be submitted through one of two methods. Section 5.11 of the CPSM – “Project Submission Requirements” covers the two methods of submitting documents:

- Electronic Documents Submission

The electronic submission method is further detailed in CPSM “APPENDIX S - DEB Electronic Document Review (EDR) Process Document”

#### **2.4.6 Distribution Lists**

The VMI POC for each project will establish internal distribution lists for VMI stakeholders. Submittals to DEB shall be in accordance with the Review Submittals article above.

Final construction submittals to the Construction Office should include two paper copies and one electronic version on electronic media.

#### **2.4.7 Presentation of Renderings**

For purposes of presenting concepts and renderings in review meetings with VMI stakeholders, VMI requires that these be mounted to rigid board and produced at 30” x 40” or another size as discussed and agreed upon.

### **2.5 PERMITTING**

#### **2.5.1 VMI’s Role as a Self-Permitting Agency**

VMI has authority to self-permit certain project types under the Annual Permit, which is internally managed and reported upon by VMI. Self-permitting is allowed only upon an initial review of the project with DEB.

Projects managed under this Permit will be Non-Capital. VMI manages its own erosion control permitting – the Deputy Director of Facilities Management for Construction and Engineering is the permitting authority. VMI manages the erosion control permitting process contracts using an external consultant.

#### **2.5.2 Involvement of Other State or Federal Agencies**

Different state agencies are involved in projects based upon scope and complexity. Some agencies that may have jurisdiction include DEB, DHR, AARB, VDOT, DEQ, USACE (for waterways) and the U.S. Forest

Service (Environmental Assessments). The VMI POC will work with the A/E to determine which agencies have jurisdiction and/or require permitting documents.

### 2.5.3 Involvement of City and County

This varies greatly by project and project location. Project sensitivity may also dictate public agency involvement. VMI will provide guidance and coordination on a case-by-case basis. CPSM includes basic public agency coordination requirements for capital projects. In some cases, DEB may ask that the design be submitted to local fire authorities to review Fire Department Connection (FDC) and Fire Alarm Annunciator (FAA) locations, accessibility for emergency service vehicles, and necessity for first responder radio repeaters. Submittals may also involve the local health department (typically for food related projects). Following is contact information for commonly needed local governmental agencies in the Lexington area:

City of Lexington – Fire & Rescue / Emergency Management

[Emergency Management | Lexington, VA \(lexingtonva.gov\)](https://www.lexingtonva.gov/emergency-management)

City of Lexington – Planning and Development

[Planning and Development | Lexington, VA \(lexingtonva.gov\)](https://www.lexingtonva.gov/planning-and-development)

City of Lexington – Police Department

[Be a Guardian of the Community | Lexington VA Police Department \(lexingtonvapid.com\)](https://www.lexingtonvapid.com)

County of Rockbridge – Fire, EMS, and Emergency Management

<https://www.co.rockbridge.va.us/193/Fire-EMS-Emergency-Management>

County of Rockbridge – Building Department

<https://www.co.rockbridge.va.us/124/Building-Department>

County of Rockbridge – Sheriff's Office

<https://www.co.rockbridge.va.us/147/Sheriff>

VA Department of Health – Central Shenandoah District

<https://www.vdh.virginia.gov/central-shenandoah/>

## 2.6 VMI FACILITY LOCATIONS

VMI manages the following properties, and this Guide is applicable to projects at all sites.

- VMI post – City of Lexington and Rockbridge County
- New Market Battlefield State Historical Park – Town of New Market and Shenandoah County
- McKethan Park (Sky Farm) – Rockbridge County
- Chessie Nature Trail – Rockbridge County
- Jackson House Museum – City of Lexington
- Lackey Park – Rockbridge County
- White's Farm – Rockbridge County

## 2.7 A/E ADDITIONAL SERVICES

### 2.7.1 Hazardous Materials (HazMat) Surveys

These studies are typically commissioned by VMI for Non-Capital projects and are included in the A/E scope for capital projects. Coordinate with VMI POC to determine if this is in the A/E scope. If hazardous materials are encountered, A/E will be commissioned to monitor abatements in most cases.

### 2.7.2 Parking Review

Parking related design features are to be coordinated through and approved as part of the overall design development.

### 2.7.3 Utility Connection

Utilities on post are public utilities. VMI is responsible for maintaining some of the infrastructure supporting the public utilities. The remainder of the sites are served by public and municipal utilities, with no VMI infrastructure. One exception is water distribution from a well at New Market.

Physical Plant (P2) and Information Technology (IT) control VMI-owned utility infrastructure on post include IT Services (security, central fire alarm, and mass notification, access control), stormwater, domestic water, sewer, and limited natural gas.

#### Utilities Available by VMI Property Location

Property Location	Utility	Provider	Notes
VMI Post - Lexington	Electricity	Dominion Energy	
	Telecommunications	Comcast (Cable)	
	Telecommunications	Brightspeed (Telephone)	
	Water	City of Lexington	
	Natural Gas	Columbia Gas	
	Sewer	City of Lexington	
New Mkt. BSHP	Electricity	Dominion Energy	
	Telecommunications	Shentel	
	Water	Private Well	
	Natural Gas	Washington Gas	
	Sewer	Town of New Market	
McKethan Park /Sky Farm	Electricity	BARC	
	Telecommunications	Comcast (Cable)	
	Telecommunications	Brightspeed (Telephone)	
	Water	Private Well	
	Sewer	Private Septic	
Jackson House Museum	Electricity	Dominion Energy	
	Telecommunications	Comcast (Cable)	
	Telecommunications	Brightspeed (Telephone)	
	Water	City of Lexington	
	Natural Gas	Columbia Gas	
	Sewer	City of Lexington	
Lackey Park	Electricity	BARC	

	Telecommunications	Comcast (Cable)	
	Telecommunications	Brightspeed (Telephone)	
	Water	Rockbridge County PSA	
	Natural Gas	Columbia Gas	
	Sewer	Rockbridge County PSA	
White's Farm	Electricity		No Services
	Telecommunications		No Services
	Telecommunications		No Services
	Water		No Services
	Natural Gas		No Services
	Sewer		No Services

#### 2.7.3.1 *Utility Locating Services*

The use of Miss Utility (811) shall be clearly and conspicuously specified on construction documents for public utility locating.

#### 2.7.4 Environmental Impact Reports (EIR)

EIR requirements are shown in the DEQ Procedures Manual for "Environmental Impact Review of Major State Facilities." VMI will work with designer to determine how the EIR is procured.

#### 2.7.5 Furniture, Fixtures, & Equipment Assistance (FF&E)

VMI may request that the A/E provide services to select and specify furnishings, fixtures, and equipment for some projects. Coordinate this activity with VMI POC who will be available to arrange communications between VMI stakeholders, VMI approved FF&E vendors and the A/E representative.

#### 2.7.6 Sustainability

Facility construction and renovations are to integrate energy and sustainability best practices to ensure VMI is a good steward of financial resources and the environment.

The Institute recognizes its responsibility as a steward of the natural resources of the Commonwealth of Virginia. Facility renovations and new construction are to be planned and constructed in accordance with the performance standards outlined in DEB Notice #121510 "Virginia Energy Conservation & Environmental Standards", available at this link:

<https://dgs.virginia.gov/globalassets/business-units/bcom/documents/deb-notices/2010-12-15debnotice121510-virginiaenergyconservationandenvironmentalstandards.pdf>

In addition, the High Performance Buildings Act (HPBA) shall apply to design projects meeting the following criteria:

Executive branch agencies and institutions entering the design phase for:

- Construction of a new building greater than 5,000 gross square feet in size, or
- Renovation of a building greater than 5,000 gross square feet where the cost of renovation exceeds 50 percent of the value of the building (see Chapter 2, definition of HPBA Building Value)



The HPBA requires that buildings meeting the above criteria be designed and constructed in accord with one of the following energy conservation and environmental performance standards:

- Leadership in Energy and Environmental Design (LEED) – Attain a minimum of 50 LEED points – Demonstrate compliance by submitting LEED certification to DEB
- Green Globes – Attain a minimum of 2 Globes – Demonstrate compliance by submitting a copy of the Green Globes certification to DEB
- VA Energy Conservation and Environmental Performance Standards – Comply with the ICC International Green Construction Code – Follow the guidance in DEB Notice # 121510 to determine which sections of the IGCC are applicable

## 2.8 ADDITIONAL REFERENCES

The A/E should become familiar with the following VMI specific reference documents:

- **VMI Post Facilities Master Plan Update (latest)**

<https://www.vmi.edu/media/content-assets/documents/finance-administration-and-support/Post-Facilities-Master-Plan-Update-2024-Final---Web-Version.pdf>

- **VMI Strategic Plan (latest)**

<https://www.vmi.edu/media/content-assets/documents/finance-administration-and-support/2024-strategic-plan-web.pdf>

- **VMI Architectural Preservation Master Plan**

<https://www.vmi.edu/media/content-assets/documents/finance-administration-and-support/Arch-Preservation-Master-Plan-Plan.pdf>

- **VMI Comprehensive Stormwater Master Plan**

<https://www.vmi.edu/media/content-assets/documents/finance-administration-and-support/RPT---08-1107---B05238-04---VMI-SWM-Planning-FINAL-Report---.pdf>

- **VMI Post-Wide Safety and Security Study, 2017**

Available upon request

## 3 HISTORIC PRESERVATION

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### 3.1 ARCHITECTURAL STYLE

The purpose of this document along with the Historic Preservation Master Plan is to provide preservation guidance and best practices in terms of the exterior building envelopes for buildings on post. The VMI post displays a rich architectural vernacular and an important collection of Gothic Revival structures dating to the mid-19th century. VMI post is a National Historic Landmark District and the Barracks are designated a National Historic Landmark.



Architects will comply with requirements found in the Virginia Department of Historic Resources and Virginia Art and Architecture Review Board (DHR/AARB).

The large Gothic Revivalist style buildings with light colored stucco, crenellated parapets, and clustered window groupings encompass the established architectural vocabulary of VMI. As stewards of these historic buildings, VMI faces challenges maintaining and preserving its architectural legacy. Current work should reflect this understanding and seek to both sustain and promote this history.



The Historic Preservation Standards, as successfully tested by the Secretary of the Interior's Standards for the Treatment of Historic Properties, help to guide changes that affect historic resources. These Standards are not rules, nor do they provide universal answers for every situation, as each building presents unique issues and opportunities. The recommendations for VMI emphasize the following approaches:

**Repair:** Conduct regular inspections and replace deteriorated sections, features, and materials promptly. Materials and workmanship should be executed in-kind, that is, matching the historic fabric.

**Replacement:** If historic features and materials are too deteriorated to repair, they should be replaced in-kind to match the form, materials, detailing, and other physical and visual qualities of the historic fabric.

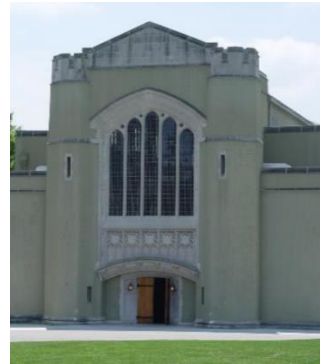
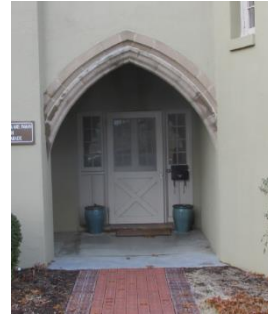
**Reconstruction:** Rebuilding missing features should only be undertaken based upon historic drawings and/or photographic documentation.

**New construction/additions:** New work should be similar in size, scale, materials, design, and color to the existing historic fabric and should not obscure or damage character-defining features. The following designs are discouraged because they confuse the historic record and diminish the integrity of the resource: 1) designs whose architectural features either mimic the historic appearance of another building or 2) designs whose architectural features are borrowed from another building.

### **3.2 ARCHITECTURAL FEATURES**

Virginia Military Institute's architectural style follows the more fortress Gothic Revival. This style was originally promoted as an appropriate design for rural settings, with its complex and irregular shapes and forms fitting well into the natural landscape. It generally is found with the following identifiable features:

### 3.2.1 Pointed Arches as Decorative Elements and as Window Shapes.



### 3.2.2 Front Facing Gables with Decorative Incised Trim

### 3.2.3 Porches with Turned Posts or Columns

### 3.2.4 Steeply Pitched Roof

### 3.2.5 Gables Topped with Finials or Cross-Bracing

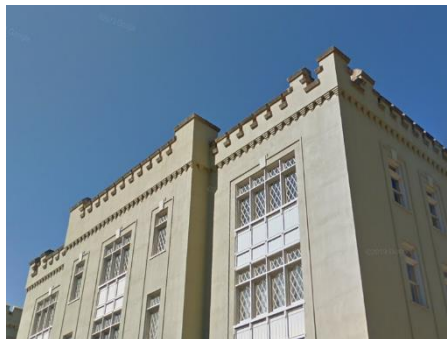




### 3.2.6 Castle-like Towers with Parapets

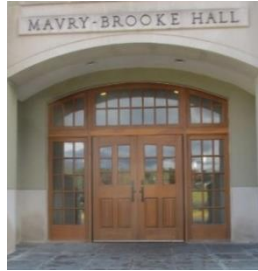
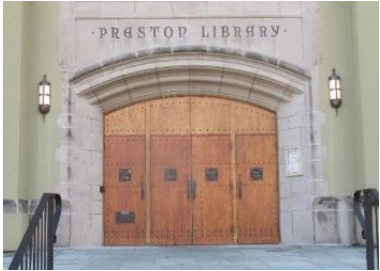


### 3.2.7 Crenellations



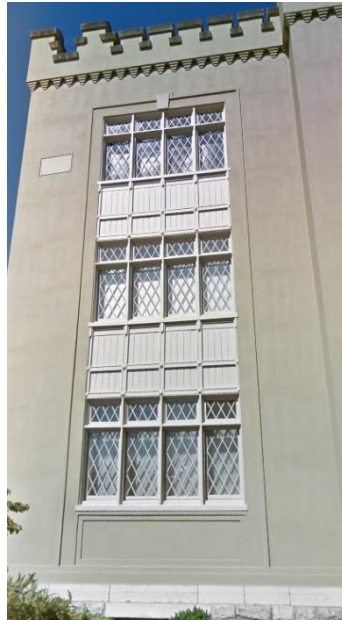
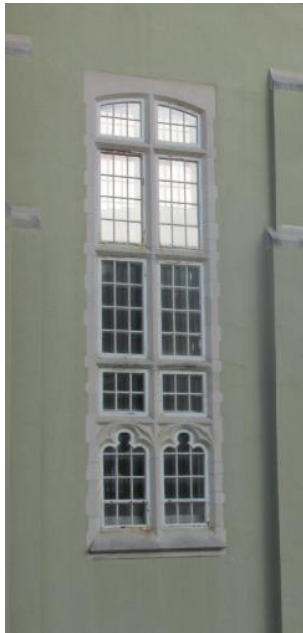
### 3.3 VMI SPECIFIC ARCHITECTURAL FEATURES

#### 3.3.1 Wood Entrance Doors



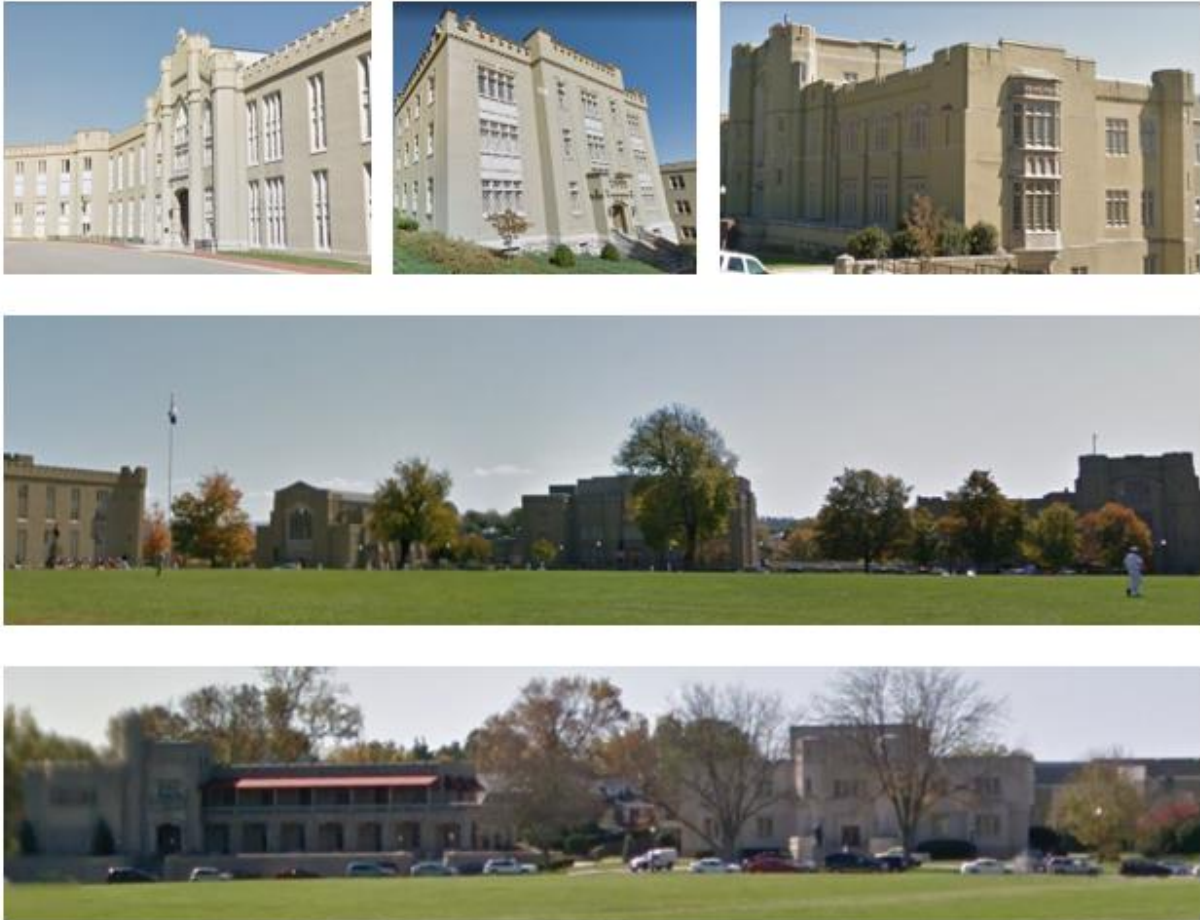
### 3.3.2 Windows

Design for windows should be sensible to the overall scale of the building and exemplify the Gothic Revival style with its detail. Preference is given to a true divided lite window.



### 3.3.3 Scale

Consideration should be given to the size and proportion of the building and its features. Features within the exterior of the building may be grouped in order to break up the scale of larger buildings. Likewise, contextual placement of structures should be considered to protect green spaces and preserve the more rural character of the post. Green and open spaces shall not be developed without approval by the Board of Visitors due to the impacts that such developments would have on the openness and the historic elements of the post.



## 3.4 SYMBOLS

### VMI Symbols and Motto

The **VMI Visual Identity Standards Manual** should be referenced prior to the use of Symbol or Motto within documents or incorporation into visual components of a building project. VMI Communications and Marketing Department is responsible for permitting the use or issuance of graphic standards related to VMI symbols. Designers and contractors should coordinate their requirements through the VMI project POC. More information on brand guidelines and identity standards can be found at [vmi.edu/about/offices-a-z/communications-and-marketing/standards-and-guides](http://vmi.edu/about/offices-a-z/communications-and-marketing/standards-and-guides).



## Coat of Arms

The VMI Coat of Arms was designed and authorized by the U. S. Army's Institute of Heraldry in 1961-1962. It bears the words *Consilio et Animis* - By Wisdom and Courage.



## Motto

*In Pace Decus, In Bello Praesidium*

*"In Peace a Glorious Asset, In War a Tower of Strength"*

The official motto of the Institute was adopted by the Board of Visitors on June 28, 1876 at the request of VMI's first Superintendent, Francis H. Smith. The Board reaffirmed this action in 1969.

## The Seal

The image on the VMI Seal is the same as that on the obverse of the Seal of Virginia. It features the Roman goddess Virtus standing over a defeated opponent. She represents the virtues of heroism, righteousness, freedom, and valor and stands in a classical victor's pose over a fallen tyrannical foe, whose crown lies on the ground. Where the Seal of Virginia bears the words *Sic Semper Tyrannis* (Thus Always to Tyrants), the VMI Seal has the inscription *Virginiae Fidem Praesto* (Faithful to Virginia). This expression was often referred to as VMI's motto during the period 1841-1875; however, it was never officially adopted as such. The seal is used in ceremonies and on building plaques and various official documents.



## The Logo (VMI Spider)

The modern VMI logo first became popular as an athletic monogram in the early 20th century. However, the use of the three intertwined initials dates to the post-Civil War period, when elaborate designs were often featured on dance and graduation invitations.



#### Primary Wordmark

VIRGINIA MILITARY INSTITUTE

#### Primary Wordmark with Identifier

VIRGINIA MILITARY INSTITUTE  
OFFICE OF THE SUPERINTENDENT

#### Secondary Wordmark

VIRGINIA  
MILITARY  
INSTITUTE  
LEXINGTON, VA

VIRGINIA  
MILITARY  
INSTITUTE  
FOUNDED 1839

#### Lettermark

VM I

#### Lettermark with Identifier

VM I  
OFFICE OF THE SUPERINTENDENT

#### Secondary Mark



## 4 SITE WORK

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### 4.1 SITE PLANNING

#### 4.1.1 VMI Annual Standards and Specifications for ESC and SW

VMI operates a Virginia Erosion and Sediment Control Program (VЕСP) and Virginia Stormwater Management Program (VSMP) through Annual Standards and Specifications as approved by the Virginia Department of Environmental Quality (DEQ). This program is managed by the Deputy Director of Facilities Management for Construction and Engineering. The annual standards document provides guidelines for ESC and SWM plan preparation and is regularly updated to reflect amendments to ESC and SWM law. The latest edition may be found on the Construction Office section of the VMI website. Plans shall be submitted to VMI for review and approval.

#### 4.1.2 Erosion and Sediment Control (ESC)

Erosion and Sediment Control requirements apply to construction projects as defined in the VMI Annual Standards and Specifications for Erosion and Sediment Control and Stormwater Management. The latest edition shall apply.

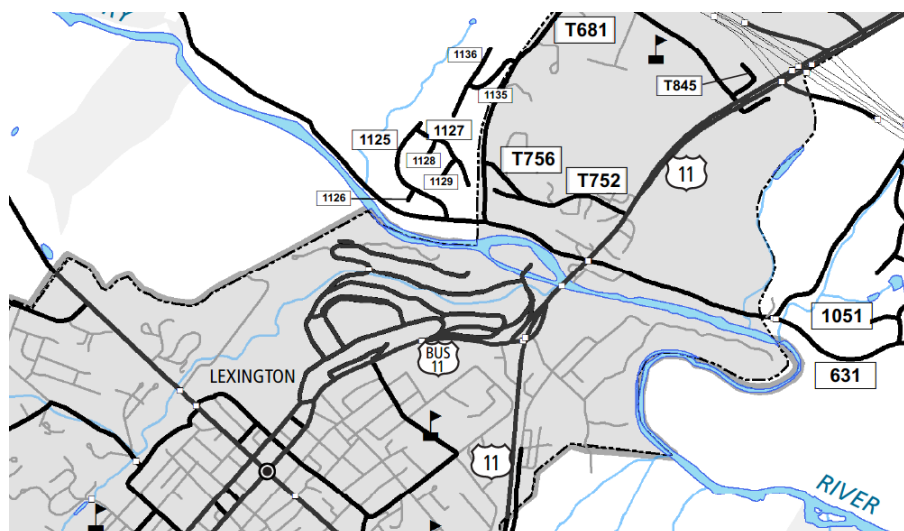
#### 4.1.3 Stormwater Management (SW)

Stormwater Management requirements apply to construction projects as defined in the VMI Annual Standards and Specifications for Erosion and Sediment Control and Stormwater Management. The latest edition shall apply. Selection of BMPs shall be made in consultation with VMI POC.

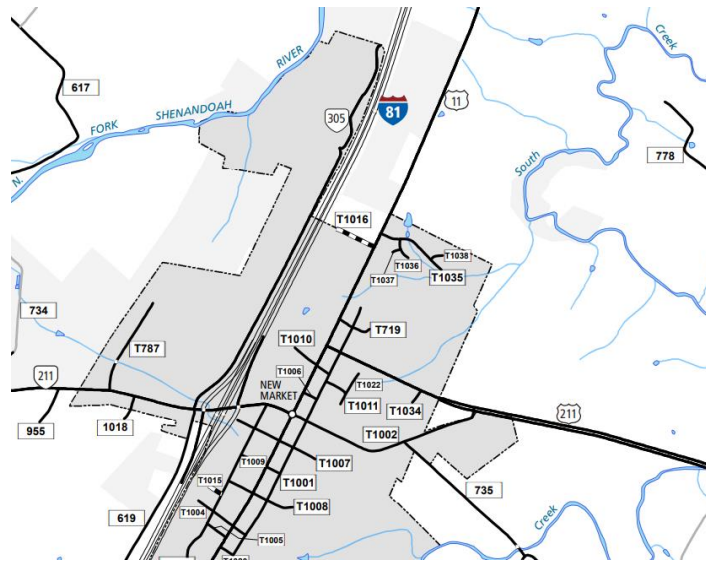
#### 4.1.4 Roads

Roads on the VMI main post are owned by VDOT. They are identified as Route Number 303 in the VDOT system. Changes to the road shall be coordinated with VDOT. VDOT standards shall be utilized for design unless otherwise specified. VMI POC will contact VDOT staff and determine the review requirements for the specific project. Review requirements will vary based on the scope of each project.

VDOT Owned Roads (Main Post)



### VDOT Owned Roads (New Market)



Cuts to the pavement for utility installation shall require a full road-width mill and overlay for the length of roadway impact. Pavement patches may be used as temporary stabilization and shall be used if trench cuts will remain for more than one week.

#### 4.1.5 Service Areas and Dumpster Policies

Service areas shall be incorporated into overall site layout to provide adequate delivery and service access from primary vehicular travel ways.

As much as possible, dumpsters shall be located rearward of all buildings. Gated decorative screening or other method approved by VMI shall be used to enclose the metal waste bin.

#### 4.1.6 Permitting

In addition to ESC and SW management permits, site planning shall include the required approvals and permits from State and Federal Agencies. Requirements shall be determined during the preliminary phase of design with permits being filed at the earliest possible time in the design process. Potential permits include:

Main Post

Local:

Flood plain certification for any work along Woods Creek within the mapped flood plain. The A/E shall confirm the applicability with appropriate local government representative. The flood plain certification shall be obtained from the local flood plain manager. If grading changes will occur an updated flood model may be required per code requirements prior to receiving the flood plain certifications. Grading or building within a flood boundary shall meet FEMA requirements.

State:

VDH and DEQ – for all modifications to the water supply (submit final plans for review and approval)

VDOT – for all modifications to roadways (submit final plans for review and approval)

Joint Permit Application (JPA): VDEQ, VMRC, ACOE – for all permanent or temporary work occurring within wetland boundaries as defined by the Clean Water Act and Virginia Wetland Resources Act. Wetland delineation shall be performed by a qualified professional.

Federal:

ACOE – obtain through Joint Permit Application (JPA) process for work taking place within the boundary of a mapped wetland area.

FEMA – grade alteration or building construction within a mapped flood plain will be directed by FEMA guidelines. Coordinate design with the local flood plain manager for specific requirements applicable to the project.

#### 4.1.7 Site Investigation

The A/E shall not rely on VMI records pertaining to site conditions as existing records are not guaranteed to be accurate. In coordination with the VMI POC, the A/E shall determine any site investigation, including underground utilities and/or structures, warranted to reasonably prevent conflict or unforeseen project cost.

## 4.2 SITE UTILITIES - PUBLIC

### 4.2.1 Sanitary

General: Virginia Sewage Collection and Treatment (SCAT) Regulations

(<https://law.lis.virginia.gov/admincode/title9/agency25/chapter790/>) and City of Lexington

Construction Specifications and Standards (City of Lexington – Public Works) shall apply to design of sanitary collection and conveyance systems.

Structures: Concrete precast manholes shall be utilized for mainline structures. City of Lexington Standard details shall apply.

Pipe: City of Lexington Standards shall apply.

City of Lexington Standards and Details shall apply for sanitary cleanout location, materials, and construction.

### 4.2.2 Storm Sewer

Drainage facilities within roadways shall comply with VDOT Standards.

([https://www.virginiadot.org/business/locdes/vdot\\_road\\_and\\_bridge\\_standards.asp](https://www.virginiadot.org/business/locdes/vdot_road_and_bridge_standards.asp))

### 4.2.3 Electrical Distribution

Medium voltage electrical duct bank shall comply with applicable standards of the National Electric Code ([https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-](https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70)

[standards/detail?code=70](https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70)). Minimum cover shall be 30-inches. Minimum duct size shall be 4-inches.

Ducts shall be separated by a minimum of 5 spacers per 20 feet of duct. Obtain the latest requirements from the local provider.

See Electrical Section for further design requirements.

#### 4.2.4 Communications

See Communications Section.

#### 4.2.5 Easements

Easements shall be prepared where provider-owned gas, power, communication or other utilities are relocated to meet plan requirements. Privately-owned service lines from the main will not require an easement.

### 4.3 SITE UTILITIES – PRIVATE

#### 4.3.1 Water

##### Water Mains

Water mains on post are owned by the City of Lexington with water purchased from the City of Lexington. The water mains range in size from 6-inch to 12-inch and are constructed of ductile iron pipe. The mains were designed and constructed under the City standards. Modifications or additions to the VMI system shall follow AWWA guidelines. To maintain continuity, where applicable, the City of Lexington standard details (City of Lexington – Public Works) shall be used. Modifications to the water supply system shall require a Waterworks Permit from the Virginia Department of Health.

##### Domestic Service

Domestic service lines shall be located in open grassed areas where possible. Ten foot minimum separation shall be maintained to sanitary sewer facilities. Connection to the main shall be made with a saddle and corporation stop for service lines 2-inches and under. Connection to the main shall be made with a tapping sleeve and valve for service lines over 2-inches. The valve size shall match the service line diameter.

##### Fire Lines

Fire service lines shall be located in open grassed areas if possible. Ten foot minimum separation shall be maintained to sanitary sewer facilities. Connection to the main shall be made with a minimum 6-inch tapping sleeve and valve when connecting to an existing line. A mechanical joint tee with 6-inch branch shall be used for new construction. The valve size shall match the service line diameter at a minimum. Fire department connection size, threading, and location will comply with local fire marshal requirements.

##### Backflow prevention

A reduced pressure principle backflow prevention assembly, double gate – double check valve assembly, or pressure vacuum breaker assembly shall be provided for all connections to the water main in accordance with City of Lexington backflow prevention program. Determination of the containment device shall be based upon the hazard level as defined by the City of Lexington Construction Specifications and Standards. Design and installation shall be in accordance with the City Standards.

#### 4.3.2 Sanitary

General: Virginia Sewage Collection and Treatment (SCAT) Regulations

(<https://law.lis.virginia.gov/admincode/title9/agency25/chapter790/>) and City of Lexington Construction Specifications and Standards (City of Lexington – Public Works) shall apply to design of sanitary collection and conveyance systems.

Structures: Concrete precast manholes shall be utilized for mainline structures. City of Lexington Standard details shall apply.

City of Lexington Standards and Details shall apply for sanitary cleanout location, materials, and construction.

Pipe: City of Lexington Standards shall apply.

#### 4.3.3 Storm

General: Site features shall incorporate standard practice for sustainable design. Best Management Practices shall be utilized for collection and conveyance of storm water flows.

Structures: Concrete precast manholes and inlets shall be utilized for in-street and mainline structures. VDOT standard design parameters shall be used.

PVC drain basins may be utilized as applicable for site drainage and upon consultation with the VMI POC.

Pipe: VDOT design standards shall apply to pipe sizing. Acceptable pipe materials include: reinforced concrete pipe, polypropylene, PVC, and ductile iron pipe. Manufacturer's guidelines shall be used to determine wall thickness requirements.

#### 4.3.4 Steam

Model analysis shall be performed for all modifications to the existing system.

#### 4.3.5 Electric

See Electrical Section for Equipment and design parameters.

#### 4.3.6 Communications

See communications Section Equipment and design parameters.

### 4.4 SITE PREPARATION

#### 4.4.1 Demolition

When buildings or structures are to be removed, procedural requirements and approvals shall be in place prior to mobilization of equipment to the site. Where applicable, asbestos and lead paint surveys shall be performed, and information included in the construction documents. Coordination with DHR and other applicable state agencies is required. Demolition shall conform to all federal, state, and local regulations for notices, safety, erosion and sediment control, environmental quality, and disposal of materials.

#### 4.4.2 Clearing and Grubbing

Clearing limits shall be clearly identified on the plans. Designs shall limit tree removal to the greatest extent possible. All material produced from clearing and grubbing operations shall be disposed in an approved landfill. On-site burning is prohibited.

#### 4.4.3 Tree Protection

Trees inside and outside of the limits of disturbance and not intended for removal shall be protected from damage. Plans shall indicate tree protection for all individual trees near the limits of disturbance that could otherwise incur damage by work activities.

#### 4.4.4 Mass and Trench Rock

Plans shall consider the potential for shallow rock elevations. Geotechnical investigations may be required to verify the elevation, depending on the size and scope of the project. Coordinate with VMI POC for the geotechnical investigation requirements. Industry standard rock removal techniques will be considered with final approval by VMI.

### 4.5 SITE DEVELOPMENT

#### 4.5.1 Construction Standards

All site elements shall conform with the design standard applicable to its construction. Those items not expressly identified within the Design Guide shall conform with: VDOT Road and Bridge Standards and Specifications, ADA Standards for Accessible Design, Virginia SCAT Regulations, City of Lexington Standards and Details.

#### 4.5.2 Coordination of Activities

Through the course of design the engineer/architect shall seek to be informed of adjacent and/or post-wide projects that may impact the project development or constructability. Thought shall be given to the project's overall impact to post activities. Conflicts shall be mitigated to the greatest extent possible. Notification and coordination with other design projects or Post Master Plans shall be accomplished.

#### 4.5.3 Site Safety

Site safety shall be the responsibility of the contractor. All local, state, and federal requirements shall apply.

### 4.6 PARKING

Parking shall be provided for new construction in accordance with the CPSM and ADA Accessibility Standards. Determination of site parking shall be achieved no later than the Preliminary Design in consultation with the VMI POC and Staff.

Minimum slope for all paved surfaces shall be 1%. Maximum slopes for parking areas shall be 7%. ADA parking spaces shall have a maximum slope in any direction of 2%. ADA travel pathways shall be designed with a maximum slope of 5%.



## 4.7 PAVEMENT AND SIDEWALKS

### 4.7.1 Curb and Gutter

Concrete curb and gutter shall be the basis of design for all paved areas unless otherwise relayed by VMI POC. VDOT CG-6 shall be the standard cross section. The curb shall remain finished concrete and not be painted.

### 4.7.2 Painting and Marking

Pavement marking shall use VDOT approved materials and installation methods. Design criteria for line work will not follow VDOT standards. A single yellow line shall be provided on the right edge of the asphalt to indicate 'No Parking' areas. Curbing will not be painted. Standard concrete finish shall remain unpainted.

Where striping is required in a hardscaped area, a differing color brick paver will be considered to create the designation.

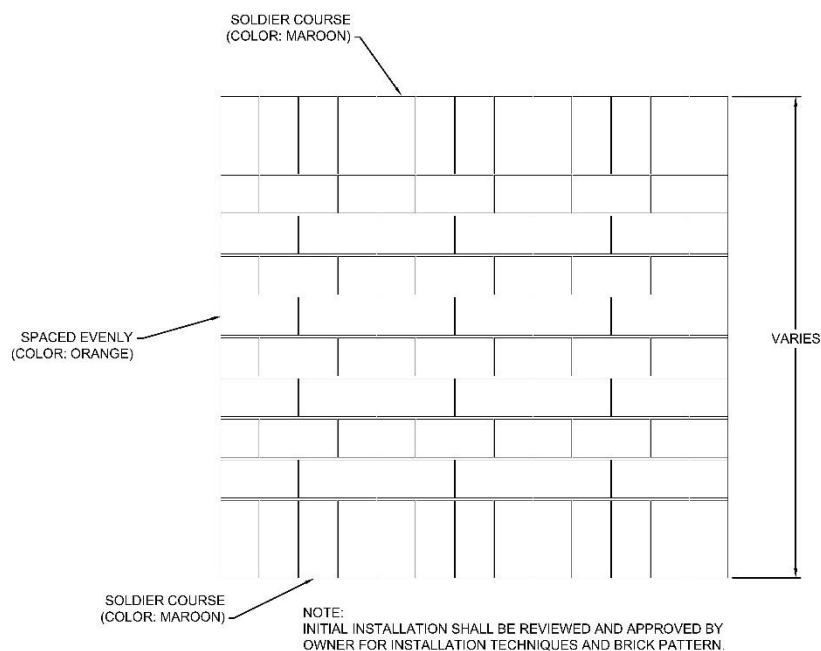
### 4.7.3 Sidewalks

Sidewalks will be provided for new construction as applicable. The minimum width shall be five feet. Wider widths shall be provided per standard ingress/egress requirements. Sidewalks may be of concrete or VMI brick pavers. Concrete specification shall include provision for reduced deterioration due to heavy salting. Coordinate sidewalk material with VMI POC. Where possible sidewalks shall be used for steam line corridors.

### 4.7.4 VMI Brick

Historic VMI brick have been developed for use in sidewalk construction and other hard surface areas. The historic pavers may be used for sidewalk or hardscaped areas as defined by the VMI POC. The paver cross section shall be developed to comply with the location and use of the hard surface.

#### Historic Paver Sidewalk Pattern



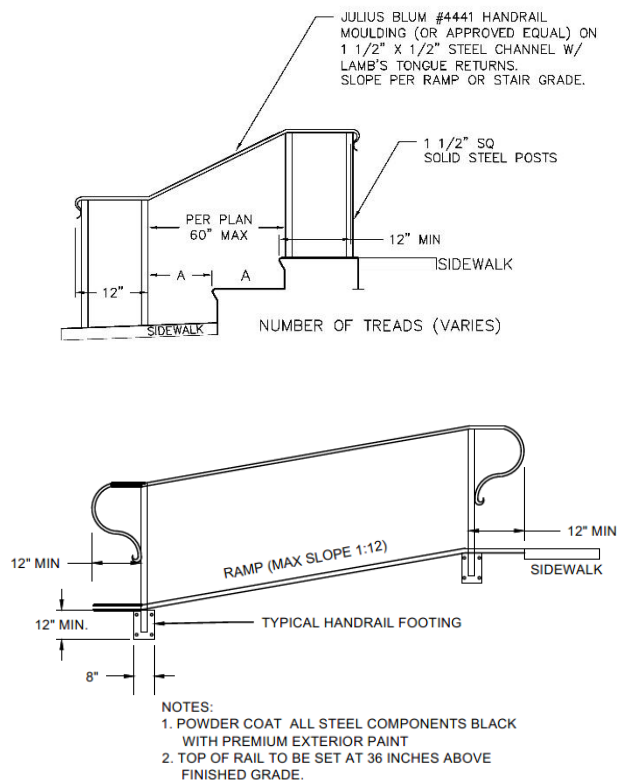
#### 4.7.5 Traffic and Pedestrian Signage

Traffic signage shall meet VDOT requirements. Signposts and backs shall be painted brown. Pedestrian signage shall be coordinated with VMI POC and specific project requirements.

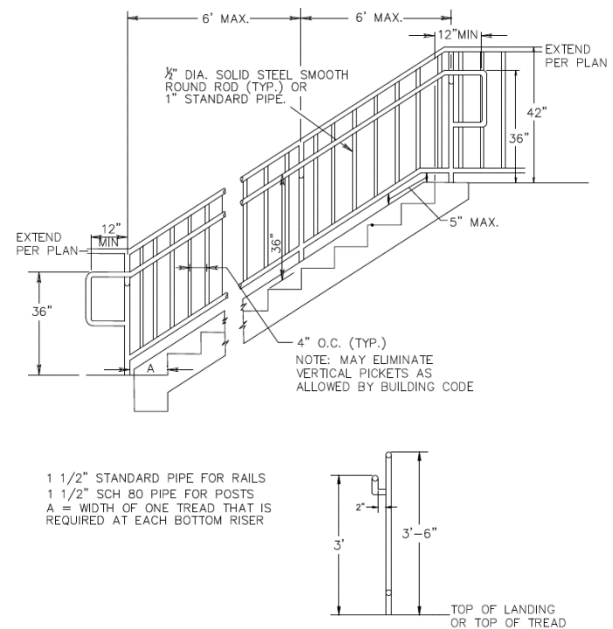
#### 4.7.6 Handrails and Stair Railings

Exterior handrails shall meet OSHA and ADA standards. Powder coating over steel railing is preferred. The handrails shall comply with one of two designs based on their location. Handrails immediately adjacent to buildings shall be Type A. Handrails in athletic areas and areas of support activities shall be Type B.

##### Type A



##### Type B



Type B ramp railing shall match construction of stair

Installation of posts into concrete shall include:

- Core drilling a hole into the post foundation a minimum of 8-inches deep
- Insert post and completely fill the void with SikaGrout to within 1-inch of concrete surface
- Fill remaining portion of void with MasterSeal NP 1 elastomeric sealant to 1/2-inch above concrete surface and dome away from post

#### 4.7.7 VDOT Standards Application

Roads on main post are owned by VDOT. VDOT criteria shall be used for modifications to existing roadways. Coordinate with VMI POC regarding VDOT review of project design.

## 4.8 HARDSCAPE

### 4.8.1 Pavers

Hardscaped areas may incorporate concrete or clay brick paver units. Pavers shall match aesthetic of surrounding area and project theme. Coordinate with VMI POC regarding use of hardscaped area and paver selection.

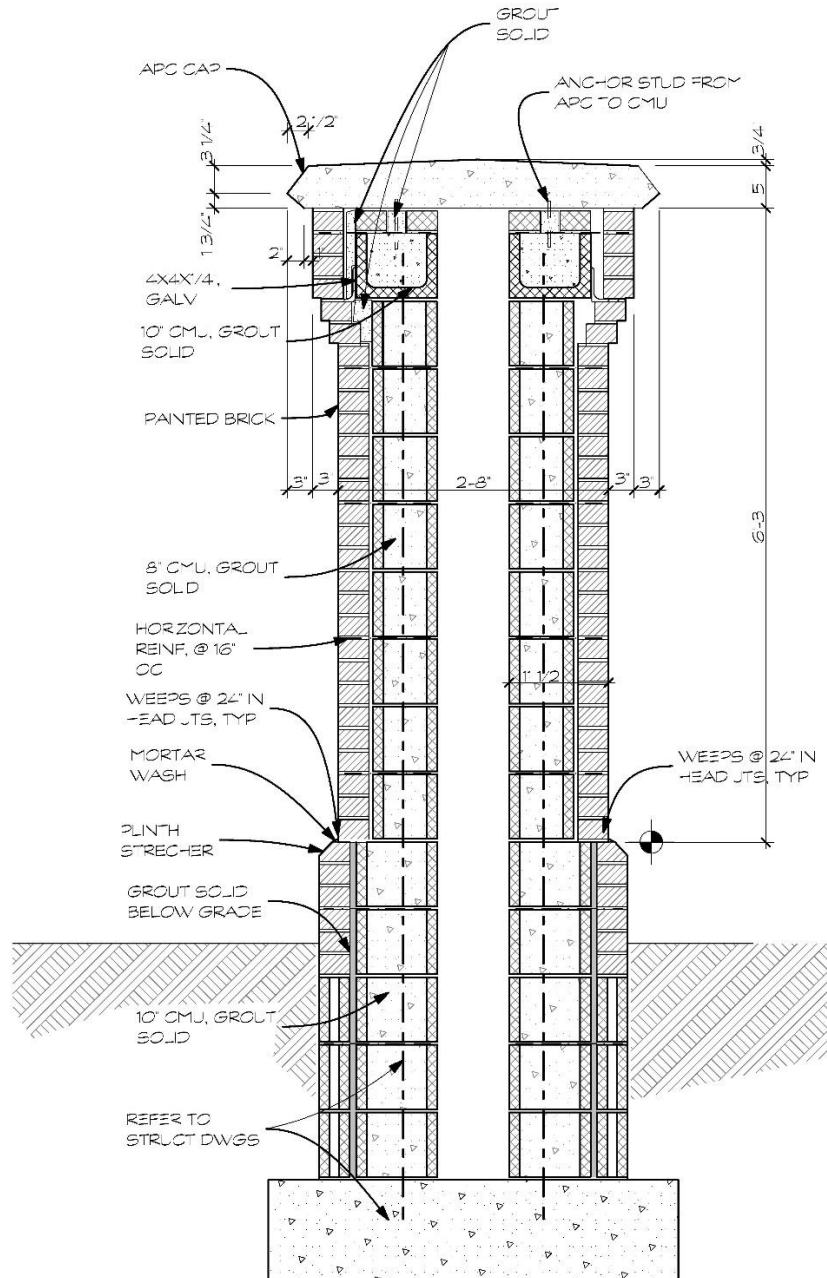
### 4.8.2 Barriers

Standard fixed bollard barriers shall be utilized for protection of site features per standard practice. Access to areas may require removable bollards as defined by VMI. When this is required, sockets will be provided for temporary storage of the bollard in a vertical position. Additionally, hand holds and locking mechanism shall be provided for ease of removal and general security. Bollard design shall consider impact resistance, mobility, and aesthetics. Bollard covers shall be used to minimize maintenance and enhance aesthetics. Covers shall be decorative and comply with the following aesthetic dependent on location and use. Other decorative options shall be considered. Selection shall be coordinated with VMI POC.



#### 4.8.3 Columns/Piers

Columns or piers may be incorporated into a site plan to define an area of prominence as indicated by the VMI POC. Column shall be designed for the structural condition and generally conform to the following:



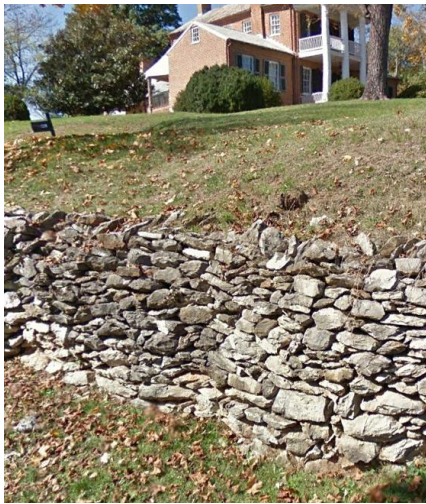
#### 4.8.4 Site Furnishing

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#### 4.8.5 Exterior Retaining Walls

Retaining walls shall be designed to support live and dead loads as applicable. Safety barriers or guardrails shall be incorporated into the wall design as required. Walls supporting VDOT roadways shall meet the VDOT design criteria and approved materials list. Retaining wall aesthetics shall match the architectural setting in which they are located. Close coordination with VMI POC, engineer, building architect, and landscape architect shall be employed through the design process. Veneers may be used in the design to meet structural and aesthetic requirements. Wall aesthetics may include dry stacked stone, mortared stone, segmental block, or stucco finish.

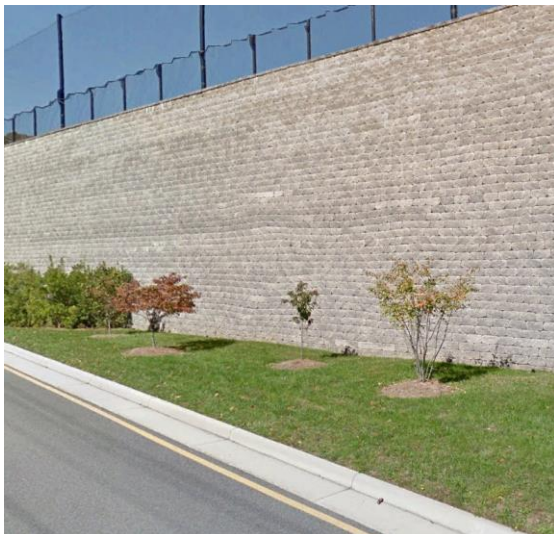
Dry Stacked Stone Wall



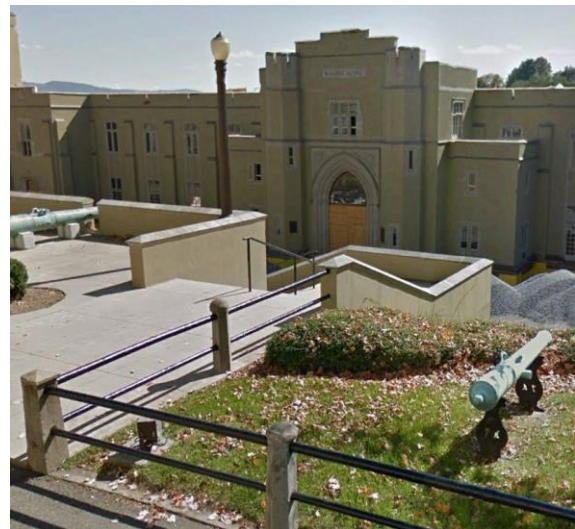
Mortared Stone Wall



Segmental Block Wall



Stucco Finish



## **4.9 LANDSCAPE**

### **4.9.1 Use of plantings**

Plantings shall be incorporated into each site plan unless otherwise directed. Plantings shall accent, not hide building features. All plants, trees, and shrubs shall be native species. Exceptions will be considered for symbolic considerations.

### **4.9.2 Approved Plant List**

Common commercially available cultivars shall be used in development of the landscape plan.

Tree selections shall include cultivars of: TO BE DEVELOPED

Tree selections shall NOT use: Ash sweet gum, magnolia, walnut, mock orange, or ailanthus altissima trees.

Shrub selections shall include cultivars of: TO BE DEVELOPED

Shrub selections shall NOT include: Boxwoods unless approved. There are native species (i.e. inkberry) that are similar. Serviceberrys should be avoided due to their susceptibility to blight and the need to be treated.

### **4.9.3 Irrigation**

Irrigation plans shall include the Hunter Head system to match existing components on Post. The Grounds Shop Supervisor shall be consulted for review and approval of design. Industry standards shall apply.

## **4.10 SITE LIGHTING**

Refer to Electrical section for site lighting standards.

## **4.11 COORDINATION WITH FIRST RESPONDERS**

See Communications section of Design Guide

## **4.12 POST-WIDE SAFETY AND SECURITY**

A Post-Wide Safety and Security Plan has been developed for providing secured access to specific areas of post. Consult with VMI POC regarding integration with project requirements. The Director of Emergency Management shall be integrated into the design process of all projects which alter or affect the operation of the Plan.

## **4.13 SITE-SPECIFIC PERMITTING**

Intentionally left blank.

## **4.14 CONCRETE**

### **4.14.1 General**

All concrete shall have a minimum 28-day compressive strength of 4,000 psi.

Concrete exposed to weather shall be air-entrained per ACI 301.

Exposed aggregate surfaces shall not be used.

Specifications shall state that positive measures are taken to assure exposed concrete surfaces are not vandalized before initial set. Contractor shall perform refinishing of vandalized surfaces at no cost to VMI.

The use of wet curing shall be required. If approved in advance by VMI, the use of a curing compound is to be limited where application of moisture is impractical, where application of such compounds will not jeopardize appearance of concrete or bond to additional concrete, and where concrete surface is to be finished with paint, tiles, waterproofing, roofing or chemical seal. Use Type 1 curing compound (except use of Type 2 on surfaces exposed to sunlight) applied with uniform thickness and other recommendations by manufacturers.

#### **4.14.2 Fiber Reinforced Concrete**

The use of polypropylene fibrillated fiber for secondary reinforcement to control surface cracking in exposed concrete slabs on grade is encouraged, and is acceptable for other exposed concrete when approved in writing by VMI. Polypropylene fibrillated fiber is not a substitute for reinforcing for structural and expansion/contraction requirements.

#### **4.14.3 Plasticizer Admixture**

Water reducing admixtures, conforming to ASTM C-494, shall be used for structural slabs and for irregular shaped structural elements that are exposed as finished architectural surfaces.

#### **4.14.4 Architectural Concrete**

The Contractor shall be required to provide a sample panel of exterior exposed concrete walls prior to construction showing all of the required finishing techniques.

#### **4.14.5 Penetrations and Openings in Concrete**

Penetrations and openings shall be located on structural drawings. Penetrations and openings larger than 6-inches shall have appropriate diagonal reinforcement around them.

#### **4.14.6 Anchor Bolts**

Structural members embedded in concrete and anchor bolts shall be galvanized or stainless steel.

Expansion anchors will not be installed in concrete where there are obvious signs of cracking or deterioration.

#### **4.14.7 Slab on Grade**

Slab on grade floors in buildings shall be a minimum 6-inch thick with WWF 6x6 W2.9xW2.9 (minimum reinforcing) for all buildings other than residential. All WWF shall be supported by chairs or concrete blocks. Reinforcing top cover shall be 1-inch minimum and 2" maximum.

#### **4.14.8 Joints**

Control and isolation joints shall be used to minimize cracking and to force cracking occurrence at joint location(s). Designers should attempt to minimize the number of joints occurring in the slab. In most cases, the maximum slab area bound by crack control joints should not exceed 324 square feet and the distance between control joints should not exceed 18-feet.

#### 4.14.9 Finish

Exposed interior concrete floors shall be sealed. A dry shake hardener shall be required where the floor surface is subject to heavy, impact, and/or rolling loads.

#### 4.14.10 Formwork

Release agents shall meet all current EPA requirements. Only non-staining water-based agents shall be used.



## 5 BUILDING SUPERSTRUCTURE AND ENVELOPE

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### 5.1 GENERAL

The building exterior shall be consistent with this document and consider **VMI Architectural Preservation Master Plan**. The objectives of the Master Plan are significantly important to merit inclusion in these standards. These guidelines encourage unity in design over time, while simultaneously allowing flexibility for positive innovation by designers.

Four objectives should be considered in determining the architectural expression of each new building, addition, or renovation to create a continuum of design across post.

- Post architecture and landscape character shall be unified.
- Views of any structure from Parade Ground should exemplify Gothic Revival style in a manner that supports the distinctive VMI architecture.
- Spacing of structures shall be considered to allow each building its own character and expression, allowing for “relief” between structures.
- Context of adjacent buildings, historical elements, and memorials

The architectural configuration and character of main post shall be preserved.

Existing barriers to unifying post, such as roads and parking should be removed (or at least minimized) wherever possible.

Building structures shall incorporate materials and detailing consistent with a building life span of not less than 50 years.

Energy conservation and management shall be optimized through an analysis of life cycle costs and an application of the LEED process during design. Registration and formal acknowledgment of this effort is not required beyond documentation of the LEED points achieved during design.

### 5.2 FOOTINGS

Over excavation shall be backfilled with #57 stone, or other approved material, and shall be approved by the Engineer of Record prior to placement.

Clean cut earth forms are acceptable for non-exposed concrete footings with prior approval by VMI and Engineer of Record.

Under-slab vapor barrier shall be continuous, extending under and around all sides of the building footing and incorporated into the exterior foundation water proofing system.

The horizontal ledge, or top of all footings, shall be parged away from the foundation and incorporated into the below grade damp or water proofing system.

### 5.3 FOUNDATIONS

All foundations shall have exterior drain tile that drains to daylight or to an approved storm water system.

Drain tile shall be located adjacent to the bottom of the footing.

Drain tile shall be protected against infiltration of stone or fine granular material by the use of a “sock” or other approved encasing material.

All foundations shall be backfilled with a 24” minimum width of #57 stone against the foundations, wrapped in landscaping fabric on all sides exposed to earth backfill.

All foundations, whether containing below grade occupied space or not, shall be fully waterproofed with both direct applied coatings and dimpled membrane.

Minimum thickness of all sub-slab and foundation vapor barriers shall be 15 mils and fiber reinforced.

#### **5.4 STEEL**

Exterior exposed steel shall be stainless steel.

Structural steel, bolts or other structural steel members shall not bear on any non-structural masonry veneer.

The welding of galvanized steel shall require a new galvanic paint coating.

#### **5.5 HANDRAILS / GUARDRAILS**

All handrails shall be anodized aluminum or stainless steel.

All handrails shall be continuous and graspable for their entire length.

All handrails shall be ground smooth and free of any burrs or other defects.

All handrail vertical standards shall be stainless steel to at least 4-inches above mounting surface or ground contact.

Fully grout base of handrails, which are core drilled into concrete to a minimum of six-inches. The base of the handrail shall have positive drainage away from the handrail.

Handrails may be left exposed or may be powder coated. Handrails shall not be painted.

#### **5.6 STAIRS / LADDERS**

Stair nosing shall be anodized aluminum with anti-skid devices, and use stainless steel anchors.

Exterior ladders of any sort shall be engineered for their intended use, meeting the requirements established by OSHA.

Alternating half step stairs/ladders are prohibited.

## 5.7 EXTERIOR WALLS

### 5.7.1 General

The use of load bearing metal stud framing in brick or other masonry exterior walls is not acceptable. Exceptions require prior approval by VMI and submission of detailed information regarding moisture barriers, stainless steel anchorage and gauge of metal studs (18-gauge (min)).

Use of Exterior Insulation Finish System (EIFS) is not acceptable. The preferred exterior finish for buildings is stucco. Exceptions require prior approval. Stucco finishes shall be multi-coat installation consisting of scratch coat, brown coat, and finish-coat, installed in three individual phases.

### 5.7.2 Stucco

Stucco is the primary exterior finish material used on post for most structures.

New Stucco shall be installed utilizing the three-coat process over wire mesh. Paper shall be Type 1, Grade D, Style 2 vapor-permeable paper. Metal lath shall meet ASTM C847, cold-rolled carbon-steel sheet with G60, hot-dip galvanized-zinc coating in expanded diamond-mesh 2.5lb/sq.yd. Furnish a foundation weep screed meeting same requirements. Scratch Coat and Brown Coat shall be applied to thickness of 3/8" each.

Finish Coat shall be two (2) coats of Tammscoat decorative and protective acrylic finish coating. Color and texture shall be Tammscoat 747 in FINE (sand) finish.

See the Guide Specification provided within this document - 09 24 00 Stucco – Cement Plastering

### 5.7.3 Exterior Stone

When exterior stone is utilized it shall be limestone or of limestone appearance. For building trim, stone shall be limited to cut or cast stone pieces. Stone trim located at window heads and door heads shall be furnished with a well-defined drip edge.

### 5.7.4 Stone Water Tables

Water tables when used shall be topped with cut or cast stone trim. The stone trim shall have through wall flashing and weeps with wicks at 24-inches on center (max). The water table may be stone or simply implied with other materials consistent with the requirements herein.

### 5.7.5 Stone Parapet Caps

When used as a field material, stone shall be furnished from a single quarry source as specified in the construction drawings and shall be pre-approved by VMI.

Through wall flashing is required at all parapets and capstones.

### 5.7.6 Stone Anchoring

All stone ties and anchors shall be stainless steel. Galvanized steel ties are not acceptable for any stonework at VMI.

### **5.7.7 Masonry**

Partially completed walls shall not be toothed, but shall be racked back at the end of each day.

All masonry shall be plumb, level and true to line. Story poles laid out with courses shall be used on all masonry construction.

All masonry shall be dampened before application to prevent the rapid curing of mortar.

When cut masonry units are necessary, only clean, square cuts shall be allowed and all adjacent head and bed joints shall be of uniform thickness.

Minimum thickness of all structural CMU walls is 8-inches.

### **5.7.8 Masonry Accessories**

Dovetail slots, and anchors shall be used for masonry veneer over concrete walls and shall be stainless steel.

Weep holes shall be rope wicks or similar approved product.

Water stops shall be built-in rubber type.

### **5.7.9 Mortar**

Masonry mortar shall not be mixed unless the outdoor temperature is above 40-degrees and rising without prior approval by VMI Construction Office. Any cold-weather mortar mixing and applications shall comply with the most restrictive provisions of the current Masonry Standards Joint Committee (MSJC) code. Mortar shall not be re-tempered.

All masonry shall have full bed and head joints. All joints shall be uniformly struck and the backsides shall not be parged. Exposed joints shall be struck in timely manner to produce an even coloration throughout the entire wall.

Cavity protection shall be provided throughout the entire installation to minimize backside mortar droppings.

All joints shall be uniformly struck and the backsides shall not be parged. Exposed joints shall be struck in timely manner to produce an even coloration throughout the entire wall.

## **5.8 EXTERIOR DOORS**

### **5.8.1 General**

All exterior entrance doors shall be a minimum of 3-feet in width.

The primary building entrance for structures on post shall be wood with wood frames.

Wood doors shall be provided with an overhead cover in order to protect the door head and the finish of the wood door. The overhead cover may be in the form of an architecturally appropriate canopy or portico type structure. The door may also be recessed into the building for protection.

### 5.8.2 Primary Entrance Wood Doors

Solid core wood doors shall be premium, five ply, 45 mm (1 3/4 ") thick minimum with stiles, rails, and cross bands bonded to core, complying with NWWDA I.S, 1-A, and AWI Architectural Quality Standards. Paneled wood doors shall be detailed and manufactured to withstand weather exposure. Use of paneled style door is restricted to the Historic District and existing buildings when it is in keeping with the established architectural treatment and in new construction when approved by VMI.

Veneer shall be minimum of 13mm (1/2"-inch) thick plain sliced premium face and edge strips.

Exterior wood doors shall be finished with 3 coats of clear epoxy sealer (System Three Silver Tip Epoxy or equal) and 5 coats of clear varnish (System Three Marine Spar Varnish or equal). Sand door between all coats per manufacturer's recommendations.

Metal frames in conjunction with the approved use of wood exterior doors shall be used in all cases except the Historic District, or where directed by VMI. Door frames shall be fully grouted.

### 5.8.3 Secondary Building Entrance(s)

Doors and Frames, which are not visible from the Parade Ground or on secondary/hidden elevation, may be metal doors within metal frames. Fiberglass doors may be used upon prior approval by VMI.

Provide 45 mm (1 3/4 ") thick doors of cold-rolled galvanized steel and of the highest grade and best model specified in ANSI A250.8 recommended in SDI 108 for each application indicated. Provide insulated doors at exterior.

Provide steel frames for doors, transoms, sidelights, borrowed lights, and other openings, according to ANSI A250.8. Conceal fastenings unless otherwise indicated. Fabricate frames with mitered or coped and continuously welded corners. Door frames shall be fully grouted.

Form exterior frames from 2 mm (0.0785") thick cold-rolled galvanized steel sheet.

Form interior frames for openings up to and including 1219 mm (48") wide from 2 mm (0.0785") thick cold-rolled galvanized steel sheet. Form interior frames over 1219 mm (48") wide from 2 mm (0.0785") thick cold-rolled galvanized steel sheet.

Other metal door materials shall be anodized aluminum or stainless steel where warranted by aesthetic and budget considerations following approval by VMI.

### 5.8.4 Center Mullions on Double Doors shall be Removable and Keyed with the Doors.

All main entrance doors along accessible routes shall be equipped with sensor or push button activated automatic doors. The location of push button activators shall be coordinated with VMI.

Entrance to be fitted with an electrical box, conduit system and power source, to accommodate a card reader, security system compatible with police monitoring. (1" conduit, 4 x 4 electrical box at appropriate ADA height on exterior of building with cover plate and a power source on the interior above the ceiling)

## 5.9 EXTERIOR DOOR HARDWARE

### 5.9.1 General

See the Virginia Military Institute Door and Hardware Facility Specification Guideline regarding door hardware.

All door closers shall be heavy-duty cast iron with a minimum 10-year warranty. Closers shall be thru-bolted to doors at a minimum height of 80-inches above finish floor.

All door closers shall be provided with compatibility for automatic hold-open devices.

All doors with closers shall have a protective kick plate.

Provide wall-mounted concave doorstops with solid blocking within wall. Floor or door mounted stops shall not be used.

### 5.9.2 Automatic Door Openers

Provide a minimum of one automatic door opener at each bank of accessible egress doors. The open switch shall be hard-wired into the emergency circuit and be provided with battery backup.

### 5.9.3 Access Control

Electronic Access Control with card readers shall be provided on all exterior doors as part of new construction and major renovations (plus select interior doors as requested by VMI). The electronic access control shall be connected to the Institute's system. Where possible, points of highest traffic shall be equipped with electronic hardware for daily locking/un-locking.

Function shall be fail secure where hardware provides free mechanical egress and no connection required to the building fire alarm system.

ADA doors with power operators shall be equipped with electric strike or electric latch retraction device and be interconnected with the electronic access controls.

If pulls are desired on both leaves of double doors, both leaves shall receive electronic hardware (i.e. both doors unlock/unlatch on card swipe). Should electric hardware not be desired on both leaves, the inactive leaf shall not be equipped with an exterior pull. Configure double doors with a single active leaf and one inactive leaf must ensure positive automatic latching of the inactive leaf whenever the active leaf is closed and latched. Manual head/foot bolts are not permitted on doors with electronic access controls.

## 5.10 EXTERIOR DOOR GLAZING

Plastics shall not be used in lieu of glass at exterior door openings.

All required safety glazing shall be laminated glass at exterior door openings.

Glazing tint color shall coordinate with existing campus aesthetic.

All wood shall be fully primed prior to glazing.

No priming shall occur over glazing. During painting, a fine bead of paint shall extend onto the glass surface.

When putty is used in the glazing process, SARCO is the preferred manufacturer.

## 5.11 EXTERIOR WINDOWS

### 5.11.1 General

Window design and selection shall consider historic significance, the window styles of surrounding buildings and the visually adjacent windows. Manufacturers of windows shall receive prior approval from VMI.

Skylights shall not be used in any occupied spaces. Preference is given to clerestory lighting should natural lighting be introduced in the space.

Plastics shall not be used in lieu of glass.

All required safety glazing shall be laminated glass.

All replacement fenestration shall meet or exceed current energy code requirements for new installations.

The extensive use of large curtain walls is not recommended. Where curtain wall or other high-percentage glazing walls are used, they shall be NFRC rated to provide a minimum total thermal resistance of at least R-6, including the frame and the glass.

Metal windows and storefront shall have thermal break frames and insulating glass. Crank operators shall not be used on operable windows.

While window replacement must be determined on an individual basis, aluminum windows reflecting the architectural detailing of the window(s) being replaced represent an acceptable alternative to wood or steel. Certain structure, such as the Barracks, must be replaced with wood windows replicating all details of the window to be replaced.

Interior side removable sashes are preferred for all operable windows for ease of cleaning and maintenance.

## 5.12 EXTERIOR WINDOW GLAZING

Double glazed fenestration is the minimum standard; however, triple glazing for exterior windows and doors will be considered if shown to provide positive payback. Provide a vacuum seal and low E glass in all new applications.

Glazing tint color shall coordinate with existing post aesthetic with prior approval by VMI.

All wood shall be primed prior to glazing.

No priming shall occur over glazing. During painting, a fine bead of paint shall extend onto the glass surface.

When putty is used in the glazing process, SARCO is the preferred manufacturer.

## 5.13 WATERPROOFING

### 5.13.1 General

The backing wall of all cavity wall systems shall incorporate a full moisture barrier into the drainage plane on tier exterior side.

All openings shall incorporate their flashing and drainage system into the wall drainage plane.

The primary drainage plane shall be located on the outside of the continuous insulation layer.

Post buildings shall not be designed with basement floor levels below the water table. The following criteria shall be met for other conditions:

1. Soils with little or no obvious water content
  - a. Water proof walls and provide protection board
  - b. Provide perforated type drainage pipe with gravel surrounding.
  - c. Backfill with suitable material with some porosity.
2. Damp to wet soils with no obvious water source
  - a. Water proof walls and provide protection board.
  - b. Provide perforated drainage pipe and surround with full height gravel to the underside of the impervious soil or material.
  - c. Provide impervious soil or material at finish grade.

### 5.13.2 Sealants, Caulking and Seals

Color and appearance are to be approved by the Post Planning Officer as part of the overall design review.

Product(s) utilized should contain polybutylene.

### 5.13.3 Flashing

All flashing within a building shall be visually and chemically compatible with all other building materials in that building.

All flashings shall be incorporated into the primary drainage plane.



All flashings shall contain drip edges to remove and discharge bulk water a minimum of ½-inch beyond the furthest face of the wall below.

The top of all windows, doors and other such openings within the veneer shall have integral drip-edge flashing. These shall also be wept to the outside. The bottoms of all windows shall have integral flashing and be wept to the outside within the first 12-inches below the opening.

All horizontal projections shall be provided with protective flashing and be designed to shed and/or weep away from the building.

Metal flashing shall be provided at stone trim, to include water tables, window heads, door heads, and parapet walls.

Metal through-wall flashing shall be 16-oz. min. copper or equivalent fabric-coated copper. Stainless steel through wall flashing may be used with prior approval of the Post Planning Officer. If stainless steel is used, it shall be Type 304 Stainless Steel meeting the requirements of ASTM A666 and shall be a minimum of 0.018 in. thick. Other metals or vinyl flashing shall not be used. All coping flashing shall be through wall type.

Provide concealed EPDM-gasketed fasteners in all flashing. Fastening shall only occur on the vertical portions of flashings.

## 5.14 THERMAL

Priority shall be given to the thermal envelope of all buildings, as it is highly cost prohibitive to make future upgrades to these areas.

The insulation of all structural elements shall be designed to prevent their interior sides from reaching their respective dew points.

New buildings shall meet or exceed their total minimum insulation requirements, through the use of continuous, exterior side insulation.

The use of cavity insulation in steel stud wall is not allowed to meet thermal insulation requirements, not excluding any requirements for acoustics or fire ratings.

Renovation work shall meet the full insulation value with continuous insulation wherever possible.

Exterior insulation of walls shall be closed-cell foam or foil-faced polyiso.

All below grade rooms (regardless of use or occupation category) shall be insulated fully and then extended, either vertically or horizontally, to a minimum depth of 24-inches below the level of the lowest slab.

The thermal envelope shall be unbroken from the top of the footing, up the walls and around the roof to the maximum extent possible.

Parapet walls shall be insulated on all sides and tops.

Low-slope roof hatches shall have a minimum insulation value of R-15.

## 5.15 PAINT

### 5.15.1 General

Paints shall be top quality acrylic or enamel. Contractor grade paint shall not be used.

Paint selections are to be made during the design process.

Paint shall be used at full thickness and shall only be thinned for required spraying applications. Spraying shall be pre-approved by VMI. Exterior building color shall be Tammscoat #747.

### 5.15.2 Paint Removal

Paint removal by open flame shall not be permitted. Where a heating process removes paint, a fire extinguisher must be available at the work site.

### 5.15.3 Lead Based Paint Removal

The location of existing lead paint shall be made known to the contractor via a hazardous materials report.

## 5.16 ROOFING

### 5.16.1 Low Slope Roofing

All low-slope roofing shall be minimally 60-mil, fully adhered, single ply EPDM roofing with minimum ½" per foot slope. 90-mil is preferred when feasible. Flat roofs are not permitted. TPO, PVC and other low-slope coverings may be considered with prior approval by VMI.

### 5.16.2 Steep Slope Roofing

All new roofing planned as metal roofing will be standing seam metal roofing. Existing steep sloped roofing of slate and tin would be replaced with like material.

### 5.16.3 Snow Guards

Snow Guards are required for all roofs with a slope of 6:12 or greater and over all entrances regardless of slope.

### 5.16.4 Gutters and Downspouts

New downspouts to be concealed within the building envelope (except for residential projects) and tied to storm water system. All low-slope roofing systems will include overflow/redundancy.

Copper gutters and downspouts shall be used on gothic buildings where they are exposed to view.

### 5.16.5 Roof Access

Roof access shall be provided from inside the building, where possible, to accommodate inspections, repairs, and general maintenance. Where access is provided on the inside of the building, the door to roof access shall be locked and accessed by card swipe.

#### **5.16.6 Ladders**

Permanent ladders or stairs, with guardrails, shall be provided to access each roof level. A grab bar extension shall be provided at the top of the stair, at roof scuttle locations, for additional safety.

#### **5.16.7 Roof Hatches**

All re-roofing project shall consider replacement of the existing roof hatches.

#### **5.16.8 Deck Pads**

All roofing shall have deck pads from roof access points to all serviceable rooftop mounted units. Construction drawings shall clearly show these traffic pad locations and dimensions. Enlarge the roof pad area at roof access points to allow for equipment staging.

#### **5.16.9 Utility Outlets**

All roofs shall have utility outlets located at or near roof top equipment. Outlets shall have ground fault circuit interrupters (GFCI).

#### **5.16.10 Rooftop Equipment**

Equipment with condensate drains to have unified collection of condensate.

#### **5.16.11 Anchoring Points**

Tie-off anchoring points shall be incorporated into all new roofing and all re-roofing projects, where tie-off points have not been previously installed.

## 6 BUILDING INTERIORS

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### 6.1 GENERAL

Historical building interiors shall be reviewed in light of their historical detailing and significance. Historical detailing shall be preserved where possible or completely restored where feasible.

### 6.2 WALLS

#### 6.2.1 General

Metal stud or masonry shall be used for all non-bearing partitions. Metal stud minimum thickness for non-bearing partitions shall be 20-gauge (0.0296 in.) and 16-inches on center. Bearing partitions shall be 20-gauge or heavier depending on loading and shall be designed in accordance with AISI S100. Demountable partitions and accordion folding partitions are prohibited.

#### 6.2.2 Fire Rated Assemblies

Specifications shall include requirements for closing of all openings in fire-rated assemblies at the close of work each day during construction.

#### 6.2.3 Gypsum Board

The minimum single layer thickness shall be 5/8-inch for walls. Abuse resistant gypsum board shall be provided in corridors, classrooms, and other similar use, high-traffic areas.

All gypsum board shall be mold resistant. All gypsum board in wet areas such as toilets, baths, janitor's closets and mop sink areas shall be mold and moisture resistant.

#### 6.2.4 Glazing

Glazing for interior partitions shall have a minimum thickness of one-fourth inch (1/4"). Glazing in interior partitions, which are 7-feet or less above the finish floor shall be tempered glass. Cross rails are required in glazed partitions at handrail height.

#### 6.2.5 Paint and Color

##### 6.2.5.1 General

Paints shall be top quality acrylic or enamel. Contractor grade paint shall not be used.

Paint for walls shall be satin and trim shall be semi-gloss. All surfaces shall be pre-primed based upon substrate. Other paint finishes require documented approval by VMI.

Paint selections are to be made during the design process and approved by VMI.

To assure economical repainting in the future, all interior classroom, office, corridor or other routine working spaces shall be painted with neutral colors similar to other instructional buildings on post.

Gypsum walls to be primed with latex primers. Walls shall have two (2) applications – prime plus one finish coat. Finish coat to be approved by VMI.

All interior wood doors to be finished natural, using two (2) coats of top quality lacquer.

Paint shall be used at full thickness and shall only be thinned for required spraying applications. Spraying shall be pre-approved by VMI.

#### **6.2.5.2 Colors**

Standard interior color is Sherwin Williams SW 6112 Biscuit. Other color shall be approved by VMI in advance during design.

Historic interior color palettes for residential buildings are based upon Sherwin Williams and include the following paints:

SW 6112 Biscuit  
SW 7757 High Reflective White  
SW 7037 Balanced Beige  
SW 2802 Rockwood Red  
SW 6218 Tradewind  
SW 0069 Rose Tan  
SW 6380 Humble Gold

#### **6.2.5.3 Paint Removal**

Paint removal by mechanical or chemical means is preferred over heat removal.

Paint removal by open flame shall not be permitted. When a heating process is used for paint removal, a hot work permit is required and approval by the Physical Plant is required. Where a heating process removes paint, a fire extinguisher must be available at the work site.

#### **6.2.6 Wall Coverings**

Wall coverings shall not be used without prior approval by VMI.

### **6.3 FLOORS**

#### **6.3.1 Floor Finishes**

All finishes shall be approved by the VMI

#### **6.3.2 Concrete Floor**

All exposed concrete floors shall be sealed. Provide a sealer hardener in high-traffic areas.

#### **6.3.3 Ceramic Tile**

Ceramic tile flooring and base shall be used in restrooms and showers with non-slip floor surfacing. Detailing shall minimize moisture penetration to concrete substrate. Cement backer board shall be used in all metal stud partition systems. The detailing on the construction documents shall include a membrane-type moisture barrier, which shall minimize moisture penetration to substrate and/or metal studs.

At all levels above grade, provide waterproof membrane complying with ANSI A118.10 and recommended for application with minimum nominal thickness of 1mm (0.040 inch). Seal around all punctures and seams with polyurethane caulking.

Provide soft joints at all inside corners where tile meets tile.

#### 6.3.4 Quarry Tile

Quarry tile floor and base shall be used in food preparation areas and shall have integral non-ferrous non-slip surfacing.

#### 6.3.5 Hardwood Flooring

Hardwood flooring, excluding athletic flooring, requires VMI approval on a project-by-project basis. When used, weather protected entrances shall prevent water damages to hardwood flooring. When hardwood flooring is approved for use over a concrete slab, a moisture barrier is required.

#### 6.3.6 Carpet

The use of separate padding under carpet is prohibited except when used in VMI post housing or authorized by VMI.

#### 6.3.7 Resilient Flooring

Resilient flooring shall be luxury vinyl tile/plank, of homogeneous solid composition, with a minimum thickness of 1/8-inch. Sheet flooring shall be vinyl, of homogeneous through composition, commercially graded flooring, with a minimum thickness of 1/8-inch.

#### 6.3.8 Resilient Base

The standard resilient base in buildings is a heavy-duty vinyl or rubber base with a minimum height of four inches. For areas subject to heavy wheeled equipment traffic or frequent maintenance buffing equipment, the minimum height shall be six inches. Outside corners shall be specified as pre-molded.

### 6.4 CEILINGS

#### 6.4.1 General

Access to all utilities above the ceiling shall be provided regardless of ceiling type used. Access panels shall be shown on the Contract Documents and locations to be coordinated with VMI Physical Plant.

The Architect/Engineer shall provide clear requirements in the plans and specifications for the proper reinforcement and support of lighting fixtures and access panels in finished ceilings.

#### 6.4.2 Suspended Acoustical Tile

The use of fire rated ceiling/floor assemblies requiring hold-down clips is prohibited unless there is no other reasonable, economical solution to achieve the required assembly rating.

The preferred ceiling tile for the vast majority of spaces on post is Armstrong 2' x 4' Georgian lay-in 763. The required color is white with a white 15/16" Prelude Grid.

The preferred ceiling tile for higher end spaces on post is Armstrong 24" x 24" Optima Tegular Fine texture 3355 tile with a 9/16" Superfine Grid Color white.

High abuse type ceiling tiles shall be used in areas such as gathering spaces, recreation spaces, and other active spaces.

## 6.5 DOORS

### 6.5.1 General

See VMI Door and Hardware Facility Specification Guideline for specific Door and Hardware requirements.

All doors shall have a minimum width of 3-feet and minimum height of 7-feet using only manufacturers standard door sizes.

All wood doors shall be five plies, solid core with a minimum thickness of 45 mm (1 3/4-inch). Specifications shall call for lifetime warranty of wood doors.

All metal door frames shall be welded construction. Hollow metal frames shall be 16 gauge, galvanized and fully grouted. Knockdown frames are prohibited.

Clear glazed vision panels shall be used in all classroom and stair doors.

Due to high maintenance and replacement costs, bi folding, folding doors or folding grilles are prohibited.

Hollow core wood doors and plastic laminated doors are prohibited.

Pocket doors are strongly discouraged.

All rated doors and frames will have labels clearly displayed. Painting over the labels is prohibited.

### 6.5.2 Locksets

Locksets shall be Schlage, heavy duty, D-series or Best, heavy duty, K-series. All interior locksets shall have lever handles with removable core.

All panic devices shall be Von Duprin, heavy-duty push type bar capable of accepting Schlage 6-pin removable core.

Hardware finish shall be as specified by the architect to meet project requirements.

Electronic Access Control with card readers shall be used where required by program and shall have an override, which is keyed to the grand master system. The electronic access control shall be connected to the Institute's system. Requests for such locks shall be submitted to VMI for approval.

Use of cypher, push-button locks or combination locks shall not be permitted.

### 6.5.3 Closers

All closers shall be heavy-duty type, of cast iron bodies, and having at least a 20-year warranty. Aluminum bodies are prohibited. Closers shall be mounted to doors with through-bolts. Floor closers are prohibited. The use of concealed overhead closers is prohibited.

### 6.5.4 Stops

Intermediate steel plates or channel reinforcement shall back knob bumpers mounted on drywall construction. Floor stops shall not be used.

#### 6.5.5 Hinges

All doors shall have ball bearing hinges. The use of floor pivot hinges is prohibited.

#### 6.5.6 Kick Plates

Door subject to abuse by equipment associated with the building function shall have a kick plate.

#### 6.5.7 Glazing

Glazing for interior partitions shall have a minimum thickness of 1/4-inch. Glazing in interior partitions, which are 7-feet or less above the finished floor, shall be tempered glass.

Cross rails are required in glazed partitions at handrail height.

Glass specified to have Underwriter's Laboratory (UL) Listing shall have the label left on the glass.

### 6.6 FURNITURE FIXTURES AND EQUIPMENT (FFE)

#### 6.6.1 Furnishings

Furnishings to be selected and purchased by VMI.

A/E shall coordinate space requirements and design for all selected furniture.

#### 6.6.2 Window Coverings

Window coverings shall be designed to reduce cooling demand for the building.

All window coverings shall be included in the construction drawings.

Window covering standards for color and style shall be determined in the preliminary phase of the project and maintained throughout the building.

### 6.7 SPECIALTIES

#### 6.7.1 General

All toilet accessories shall be stainless steel for increased longevity.

No through partitions accessories permitted.

Accessories shall accommodate the products used by VMI.

#### 6.7.2 Toilet Accessories

##### 6.7.2.1 *Soap Dispensers*

Contractor shall coordinate with Physical Plant and provide soap dispensers, which match the current Physical Plant supplier contract

##### 6.7.2.2 *Mirrors*

Provide a stainless steel edge mirror above all lavatories.



#### **6.7.2.3 Waste Receptacles**

Provide built-in waste receptacles with a minimum capacity of 18-gallons in all toilet rooms having more than one lavatory.

Separate, stand-alone, trash receptacles shall be provided in high traffic restrooms.

#### **6.7.2.4 Paper Towel Dispensers**

Paper towel dispensers shall be surface mounted. Dispenser shall accommodate the products used by VMI.

#### **6.7.2.5 Toilet Tissue Dispensers**

Contractor shall coordinate with Physical Plant and provide toilet tissue dispensers, which match the current Physical Plant supplier contract.

#### **6.7.2.6 Sanitary Napkins**

Contractor shall coordinate with Physical Plant and provide Sanitary Napkin dispensers/disposals, which match the current Physical Plant supplier contract.

#### **6.7.2.7 Toilet Partitions**

Commercial quality floor supported, overhead braced toilet partitions are required. High-density polymer resin or stainless steel are required. Exposed particleboard or wood toilet partitions are prohibited.

#### **6.7.3 Fire Extinguishers Cabinets and Fire Extinguishers**

Fire extinguisher cabinets shall be incorporated into all projects where required by code and sized for the required extinguisher.

#### **6.7.4 Interior Signage**

ADA and other code-required Interior signage shall be provided within construction contracts.

Wall mounted directories are required for new buildings, additions, and renovated structures.

All signage shall be attached to walls with adhesive or approved sign holders. Signage shall not be attached to doors.

#### **6.7.5 Wall and Corner Guards**

Wall and corner guards are required in corridors and other areas where service carts, moveable equipment, beds and such similar equipment may typically be used. Plastic guards are prohibited.

#### **6.7.6 Chalkboards**

Use chalkboards of either 1/4-inch to 3/8-inch natural slate or laminated porcelain enameled steel with butted panels. All chalkboards will have trim and full width chalk trays, two-inch tack strip with map rails as an integral part of the chalkboard assembly head trim in all classrooms. Include accessories for map rail use.

#### **6.7.7 AED (Automated External Defibrillator)**

An AED box should be installed on each floor of the building in a central location near the most used space(s) of the building. The box should be located such that the centerline of the handle is forty-eight inches above the floor level.

## 6.8 STAIRS

### 6.8.1 General

Stairwells to be finished with durable materials.

Exterior entry/exit landing to be provided with either a walk off mat or recessed entry mat.

### 6.8.2 Finishes

Rubber non-slip stair treads shall be provided on all interior stairs. For non-egress stairs, prior approval from VMI required for use of non-slip nosing and tread materials, which match flooring of the surrounding space(s).

## 7 BUILDING SERVICES

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### 7.1 ELEVATORS

#### 7.1.1 General

ThyssenKrupp is the preferred elevator provider. Other manufacturers require prior approval by VMI. Elevators shall not be used for access to roofs or other parts of the building.

Traction-type elevators are not permitted.

The electric fused disconnect switch for the elevator shall be adjacent to the door jamb of the main access door to the machine room.

Elevators, which serve the general public visiting post, shall have upgraded finishes supporting the function of the building itself.

#### 7.1.2 Elevator Pit.

Elevator pits shall have sump pits with sump pump. Drainage from the elevator pit shall not be connected to any building drainage or sewer system. Sump pits shall be equipped with a float sensor connected to an audible and visual alarm panel in the elevator machine room.

Sump pump shall be drained to an oil water separator with tank storage located within the building in a utility space. The outflow from the storage tank shall be the post storm water system.

#### 7.1.3 Control Systems.

Control Systems shall be non-proprietary and shall not require a battery to maintain programming. Control System shall be microprocessor based for dispatch and motor control, capable of computer-based monitoring with terminals for connection.

#### 7.1.4 Warranty Service Requirements.

The specifications shall be explicit regarding: "Contractor shall provide four (4) sets of all electrical wiring diagrams, access codes or passwords required for all maintenance functions, including diagnostics, adjustments and parameter reprogramming. Tools may be hand held or built into the control system, and shall function for the lifetime of the equipment. Tools that require recharging or reprogramming shall not be used. All tools, adjusters, manuals and schematic wiring diagrams become the property of VMI to be used at their discretion related to the installed elevator or elevators." Prior to the end of the warranty period, the Elevator Contractor shall readjust the elevator as required to meet all performance parameters specified. A written report shall be submitted by the Elevator Contractor to Physical Plant.

### 7.2 MECHANICAL / HVAC

#### 7.2.1 General

##### 7.2.1.1 *Steam*

The Heat Plant provides high pressure steam to many buildings on post. The distribution of steam from the Heat Plant is comprised of three main branches: one serving Academic Row (60 psig), one serving New and Third Barracks (100 psig), and one serving Burma Road facilities (60 psig).

#### **7.2.1.2 Chilled Water**

Post does not have a central chilled water system.

#### **7.2.1.3 Utilities**

Mechanical equipment shall always be designed to utilize existing post-wide utilities or building utilities when available. Confirm available capacities of existing systems prior to adding new loads.

Designers shall consider sharing of utilities between buildings when practical to provide redundancy and take advantage of incremental loading of equipment; e.g. chilled water, heating water.

Utilize natural gas for equipment when appropriate and available. Columbia Gas is the service provider on main post.

#### **7.2.1.4 Equipment and Systems**

Designers shall consult with VMI at the Conceptual or Schematic Design stages when selecting mechanical system types.

All mechanical equipment and distribution systems shall be contained within the building envelope when practical. Refer to Architectural guidelines for placement of equipment on rooftops or grade.

Information Technology (IT) spaces shall be provided with redundant cooling delivered by independent systems.

Belt-drive fans shall not be installed on small horsepower fan applications.

All HVAC designs shall consider noise criteria (N.C.) for fans relative to the installed application and N.C. levels shall be specified.

Specifications for renovation work shall require disconnection and sealing of ductwork during construction to prevent construction debris from entering the system.

Novel HVAC systems (passive downdraft, chilled beam, etc.) shall not be installed on post without prior approval.

Specifications for equipment shall include a requirement for original equipment manufacturer (OEM) representatives to conduct all warranty work.

The following space temperature set points shall be utilized. Consult with Physical Plant to verify the temperature set points below are current.

- Room unit temperature set points
  - a. Occupied        70°F heating, 72°F cooling
  - b. Standby         68°F heating, 74°F cooling
  - c. Unoccupied     55°F heating, 80°F cooling
- Local set points

- a. Wall module high limit                      73°F
  - b. Wall module low limit                      69°F
- Alarms
  - a. Space temperature alarm delay                      7,200 seconds
  - b. Space temperature alarm set point                      5°F

### 7.2.2 Water Treatment

VMI holds a contract with a water treatment service company. Consult with Physical Plant staff for specific requirements for specific water treatment systems that conform to the current practices of the current service provider.

Water provided to post is typically hard. Designers shall consider appropriate water treatment systems based on expected water hardness and the application of equipment being installed.

The use of propylene glycol is preferred for freeze protection of hydronic systems. Systems utilizing propylene glycol shall be sized accordingly to compensate for the capacity de-rate caused by the use of propylene glycol.

### 7.2.3 Humidification

Direct injection of post-wide steam for humidification is prohibited. Indirect humidifiers must be used when utilizing post-wide steam.

Canister type humidifiers shall not be used.

All make-up water for humidification shall be softened.

### 7.2.4 Cooling Towers

Single cell cooling towers shall not be installed unless serving non-critical cooling needs and approved by VMI.

Passivation for new towers shall be provided by a manufacturer's representative in consultation with the current water treatment service provider.

All cooling towers shall be furnished with necessary ladders, rails, and platforms to provide safe access for maintenance personnel.

Cooling tower basins shall be constructed of stainless steel.

Cooling tower basins shall be provided with adequate means of enclosure(s) to prevent the entry of debris into the basin.

### 7.2.5 Chillers

Air cooled chillers are preferred by the Institute. Consult with VMI for approval prior to incorporating water cooled chillers into any design.

Oil-free and magnetic bearing centrifugal chillers shall not be incorporated into designs without prior approval.

Chillers with shell and tube heat exchangers are preferred. All air-cooled chillers shall be equipped with factory installed freeze protection.

Designs shall consider the provision of connections for temporary or emergency chillers in the event of replacement or maintenance.

All chillers shall be equipment with means to communicate over BACNet protocol to the post-wide BAS system.

The following chiller manufacturers shall be listed as allowable in project specifications:

- Trane
- Daiken
- Carrier

#### 7.2.6 Air Handling Units

Air handling units shall be located within the building if possible. If adequate space is not available within the building, air handling units shall be located on the roof when feasible given architectural restraints (refer to Architectural guidelines). Locating units on grade is the least preferable location. The Designer shall strive to incorporate sufficient mechanical space within the building to prevent exterior equipment installations.

#### 7.2.7 Split Systems

Water source heat pump systems and variable refrigerant flow (VRF) systems are an acceptable alternative to four pipe variable air volume (VAV) systems in specific situations. Designers should consult with VMI prior to specifying such system for installation.

When designing variable flow refrigerant (VRF) or multi-zone systems, the Designer shall only group spaces of similar usage and exterior exposure on the same zone to prevent conflicting calls for heating/cooling. Interior and exterior spaces shall never be served by the same zone.

Heat recovery between zones shall always be considered for multi-zone and VRF systems and incorporated when practical.

All refrigerant piping connected to branch circuit controllers in VRF systems must have isolation valves at the branch circuit controller to allow for service of individual zones. Isolation valves can be provided from the manufacturer as an assembly with the branch circuit controller or be field installed.

#### 7.2.8 Steam & Condensate

##### 7.2.8.1 System Operation

Every building on post served by the post-wide steam system shall have a steam pressure reducing station. Shutoff valves shall be provided on all branch lines, all equipment connections, and on both sides of every pressure reducing valve (PRV's).

Condensate for buildings served by the Heat Plant shall return condensate in a parallel arrangement with the main post condensate return system to reduce potential condensate return losses. Building condensate shall not be tied into the post condensate return system in a series arrangement.

Condensate shall be returned to the Heat Plant by a gravity or condensate pumps. Condensate pumps shall be sized capable of returning condensate to the Heat Plant without the use of downstream pumps.

#### **7.2.8.2 Equipment**

Steam pressure reducing stations shall be designed for 1/3 2/3 operation.

All steam condensate pumps shall be duplex steam pressure powered unless otherwise approved by VMI. Spence or Armstrong are the preferred manufacturers.

Spence Engineering is the preferred manufacturer for pressure reducing valves.

Condensate pumps, whether electric or steam powered, shall be equipped with a high level alarm switch and connected to the post-wide BAS for remote monitoring; refer to Section 7.5.

The following manufacturers are acceptable for pressure reducing valves (PRVs):

- Armstrong International, Inc.
- Spence Engineering Company, Inc.
- Spirax Sarco, Inc.

The following manufacturers are preferred for thermostatic steam traps:

- Armstrong International, Inc.
- Spence Engineering Company, Inc.
- Nicholson

The following manufacturers are preferred for F&T and inverted bucket steam traps:

- Armstrong International, Inc.
- Spence Engineering Company, Inc.
- Hoffman Specialty
- Spirax Sarco, Inc.

#### **7.2.8.3 Materials**

All steam system components shall be rated for 150 psig minimum.

All steam pipe shall be Schedule 40 ASTM A106 seamless black carbon steel pipe. Other materials require prior approval.

All condensate pipe shall be Schedule 80 ASTM A106 seamless black carbon steel pipe. Other materials require prior approval.

All steam and condensate pipe 2-inches and smaller shall be threaded.

All steam and condensate pipe 2 ½ -inches and larger shall be welded.

Physical Plant maintains a labeling/indexing scheme for all steam traps utilizing RFID technology. Consult with Physical Plant staff during design to identify tags for new traps and/or incorporate tagging scheme and requirements into project specifications.

#### 7.2.8.4 *Flow Meters*

Steam flow meters shall be provided on all high pressure steam services to buildings. Flow meters must be integrated into the building BAS or provide communication through BACNet protocol. The following manufacturers are preferred:

- Endress + Hauser
- Foxboro
- Rosemount

#### 7.2.8.5 *Expansion Joints*

Flexible braided hoses are the preferred expansion joint for low pressure steam lines.

Slip-joint packed expansion joints are preferred for high pressure steam lines.

#### 7.2.9 *Boilers*

All new systems shall utilize high mass condensing type boilers unless otherwise approved. Renovations and upgrades shall utilize them where existing equipment and systems will allow for their proper operation.

Designers shall consider the implementation of summer time boilers to serve minimal space reheat or domestic hot water for priority facilities that would be significantly impacted by a loss of heating water or steam.

#### 7.2.10 *Heat Exchangers*

Shell and tube style heat exchangers are preferred.

#### 7.2.11 *Exhaust Systems*

Exhaust fans shall be variable speed using either an ECM motor or VFD. Small horsepower applications shall be direct drive.

Exhaust fans shall be installed in accessible locations for repair and maintenance.

#### 7.2.12 *Freeze Protection*

Designer shall consider the use of both glycol and heat tracing to provide freeze protection for hydronic piping susceptible to freezing. Glycol is the preferred means of freeze protection if only one method is used. Propylene glycol shall be used.

#### 7.2.13 *Insulation*

The following insulation types are preferred for the corresponding services:

- Steam and condensate                      fiberglass, mineral wool, aerogel
- Chilled water                                  elastomeric, cellular glass, polyisocyanurate

Pipe insulation installed in areas exposed to weather shall be provided with an aluminum jacket and sealed with caulk.

Pipe insulation installed inside buildings and susceptible to foot traffic shall be provided with a PVC jacket.



#### 7.2.14 Identification

Identification of piping and ductwork shall adhere to ANSI/ASME standard A13.1.

Consult with Physical Plant staff for latest tagging scheme standard.

Valve tags shall be of brass construction with black depressed lettering measuring ½-inch minimum. Tags shall be secured with brass wire-link chains.

Pipe labels shall be pretensioned semirigid plastic formed to cover the full circumference of the pipe and fastened around the pipe with straps. The use of adhesive stickers for pipe labeling is not allowed. Pipe labels should include service identification and service flow arrows. Pipe labels shall be provided in visible locations.

Systems with paired equipment located indoors and outdoors shall be provided with labeling indicating the tag name of the paired equipment.

All equipment tagging shall include location of source power and circuit.

### 7.3 ELECTRICAL

#### 7.3.1 General

##### 7.3.1.1 *Design Standards*

Electrical design shall be in accordance with the latest adopted standards of the National Fire Protection Association (NFPA), National Electric Code (NEC), and the National Electrical Safety Code (NESC). The design shall also comply with the applicable state and municipal laws and codes, including the Virginia Uniform Statewide Building Code.

##### 7.3.1.2 *Material*

All material shall conform to the latest issue of all applicable standards as established by the National Electrical Manufacturer's Association (NEMA), American National Standards Institute (ANSI), and Underwriters' Laboratories, Incorporated (UL). All equipment and material, for which there are UL standards, shall bear UL label of approval for use intended.

##### 7.3.1.3 *Identification*

All electrical equipment and circuits shall be marked and labeled for identification and safety purposes. Laminated plastic nameplates shall be used on the exterior surfaces of all electrical equipment. Nameplates may be either fully-adhered or screw-type.

##### 7.3.1.4 *Calculations*

The following calculations shall be submitted with the contract documents:

- Building short circuit and ground fault
- Building load
- Feeder voltage drop
- Generator load calculations
- Normal lighting
- Emergency lighting (indoor and at exterior of exits)

- Arc flash hazard analysis

#### **7.3.1.5 Demolition**

All wire shall be removed back to the last active device, junction box, or panelboard. All exposed and/or accessible conduit and boxes not to be reused shall be removed. The contractor shall coordinate the disposal of all hazardous materials with the Physical Plant.

#### **7.3.1.6 Testing**

All electrical systems shall be inspected and tested prior to acceptance. Inspection is to be conducted by the Engineer of Record or by a DEB representative if the Engineer of Record is not available. All testing shall be in accordance with the International Electrical Testing Association (NETA) Acceptance Testing Specifications, manufacturer's recommendations or other approved testing standards in accordance with the project specifications. An independent testing company shall perform testing unless this requirement is specifically waived by VMI.

#### **7.3.1.7 Record or As-built Documents**

At a minimum, electrical as-built document shall contain the following information:

- Location of all underground electric lines and pull boxes
- Location of all conduits in and/or under slab
- Location of all device boxes in slab
- Location/routing of all conduits greater than 1" and any associated pull boxes
- Location of all transformers, panelboards, switchgear, etc.
- Final one-line and/or riser diagram to include the final fuse sizes
- Final circuit numbers for all devices and final panel schedules
- Final manufacturer and make for all fixture types
- Exterior lighting information
- Final location of all exit and emergency lighting

Any deviations from the original contract documents shall be clearly noted in the as-built documentation.

Preferred format for as-built records is red-lined information created electronically in PDF copies of the contract documents. Hand drawn documents are not acceptable. If specifically indicated by project specifications, as-built records may be required to be submitted in a CAD or BIM format.

### **7.3.2 Service and Distribution**

#### **7.3.2.1 Local Utility**

The VMI post purchases electric power for its facilities from Dominion Virginia Power. Dominion owns and maintains all primary equipment, feeders, and three master meters for billing purposes. Dominion also serves the remainder of the VMI sites as listed in Section 2.7.3, *Utility Connection*. New services shall be connected to Dominion's distribution system. To initiate a new service, the A/E shall prepare a "Load Letter" and provide it to VMI Physical Plant for review. Physical Plant will then submit the letter to Dominion.

#### **7.3.2.2 Service Voltage**

Secondary service to buildings and facilities shall be 480Y/277V or 208Y/120V. Both systems shall be 3-phase, 4-wire WYE connected.

#### **7.3.2.3 Equipment Location**

Switchgear, switchboards, transformers and panelboards, shall be enclosed in appropriate dedicated electrical rooms. These rooms shall be separate from any mechanical rooms, IT rooms, and housekeeping closets. The main electrical room shall have direct exterior and interior access. In multi-floor buildings, electrical closets on each floor shall be stacked to the greatest extent possible.

#### **7.3.2.4 Bus Material**

For switchgear, switchboards, and panelboards, bussing shall be copper. Separate neutral and equipment grounding busses shall be provided.

#### **7.3.2.5 Metering**

Metering shall be installed in each building main switchboard as a minimum. When panelboards are used as main service equipment, the same meter shall be installed adjacent to it and provisions for current transformers and other connections shall be made. Separate metering for large loads, such as chillers, may be required. Metering shall be digital with an output tied to the BAS.

#### **7.3.2.6 Surge Protection**

Provide transient voltage surge suppression (TVSS) at the service entrance for new buildings and major renovations. Internally mounted TVSS units are not permitted. TVSS units shall be mounted externally to the switchgear, switchboard, or panelboard.

#### **7.3.2.7 Spare Capacity**

All new panelboards and feeders shall have 40% spare capacity both electrically and physically for future use. Provide spare conduits stubbed out into an accessible ceiling space for new recessed mounted panelboards.

#### **7.3.2.8 Circuit Breakers**

All circuit breakers shall be a minimum of 20A rated.

#### **7.3.2.9 Generator Provision**

Service entrance equipment shall have provision to attach an external generator of a size sufficient to power the entire building.

#### **7.3.2.10 Transformers**

Dry-type transformers shall have copper winding and meet or exceed the requirements of NEMA TP-1 for energy efficient transformers. K-factor transformers shall be used where large quantities of harmonic producing loads are present. Associated feeders shall also be sized to accommodate anticipated harmonic loads.

#### **7.3.2.11 Manufacturers**

The main components of the low voltage electrical distribution system shall be by the following manufacturers:

- Schneider Electric / Square D
- Eaton / Cutler Hammer

- Siemens
- General Electric
- ABB

### 7.3.3 Devices

#### 7.3.3.1 Ratings

All wiring devices shall be heavy-duty specification grade. Residential grade devices are not permitted.

- Switches for lighting and similar loads shall be rated 20A, 277V regardless of system voltage, and shall be back and side wired with clamp connectors.
- Convenience receptacles shall be 3-wire, grounding type, rated 20A, 125V and shall be back and side wired with clamp connectors.
- GFCI receptacles shall be feed-thru type, duplex, and rated at 20A.

#### 7.3.3.2 Device Color and Covers

All devices shall be Ivory, unless otherwise indicated or required by the NEC. Device covers shall be thermoplastic and the color shall match the device color.

#### 7.3.3.3 GFCI Protection

Provide ground-fault circuit-interrupter (GFCI) protection for personnel in all spaces as required per the NEC. At a minimum, provide GFCI receptacles on dedicated circuits at the following locations:

- Each entrance foyer, stairwell, and at least every 50' in all hallways for housekeeping
- Building exterior by entrances (front and back) and every 100' for maintenance purpose
- Rooftop equipment, electrical rooms, elevator rooms, mechanical rooms, maintenance storage rooms, trash rooms, and within 10' of serviceable equipment.
- Vending machines

#### 7.3.3.4 Wet or Damp Locations

Provide weatherproof in-use cover for receptacles installed in wet or damp locations.

#### 7.3.3.5 Welding Receptacles

Each mechanical room shall have a three-phase, 50A, 250V welding receptacle.

#### 7.3.3.6 Labeling

Label all receptacles with panel designation and circuit number.

#### 7.3.3.7 Multioutlet Assemblies

Multioutlet assemblies such as Wiremold shall be limited to renovation projects, and shall require prior approval from VMI Physical Plant. The pre-existence of multioutlet assemblies does not constitute permission to add multioutlet assemblies.

#### 7.3.3.8 Enclosures

Enclosures for motor starters, control cabinets, or other device enclosures used where they may be subject to overhead leaks, flooding, or infestation by vermin or wildlife, shall be a NEMA 4X enclosure at outdoor locations and NEMA 4 at indoor locations.

### 7.3.4 Wiring

#### 7.3.4.1 Conductor Type

All building wire shall be 600V, single conductor, and copper, with a minimum temperature rating of 75°C (THWN/THHN). Insulations with a higher temperature rating shall be used where conductor temperatures would exceed 75°C. The use of aluminum in lieu of copper shall require prior approval from VMI Physical Plant.

#### 7.3.4.2 Stranding

Conductors #10 AWG and smaller shall be solid and #8 AWG and larger shall be stranded. Exceptions will be made for control and signal wiring.

#### 7.3.4.3 Minimum Size

The minimum conductor size by application shall be as follows:

- Power and lighting - #12 AWG
- Control - #14 AWG
- Signal - #18 AWG (unless otherwise recommended by manufacturer)

#### 7.3.4.4 Color-coding

Conductor color-coding shall match the existing building convention. If none exists, the default phase colors for 208/120V systems shall be A-Black, B-Red, C-Blue, N-White, and G-Green. The default phase colors for 480/277V systems shall be A-Brown, B-Orange, C-Yellow, N-Grey, and G-Green.

#### 7.3.4.5 Conductors in a Raceway

The number of conductors in each conduit shall not exceed five (including the grounded conductor and grounding conductor) without specific permission from VMI Physical Plant.

#### 7.3.4.6 Neutral Wire

Neutral wires shall not be undersized.

#### 7.3.4.7 Equipment Grounding Conductor (EGC)

All new circuits shall have a separate EGC sized per NEC 250. The use of raceways in lieu of separate equipment grounding conductors is not acceptable.

#### 7.3.4.8 Bonding and Grounding

Bonding jumpers shall be designed at all locations required by the NEC. A main grounding conductor shall be designed to bond the largest cold water pipe at the pipe's entrance to the building. Add supplemental grounds as required by the NEC. When appropriate, grounding connections shall be exothermic welds by the Cadweld Co. or equivalent.

#### 7.3.4.9 Pre-wired Flexible Conduit

Pre-wired flexible conduit (Type MC Cable) is not permitted, except when fixed in existing walls and used as a whip from the last junction box to lighting fixtures. Fixture whips shall be no more than 6' in length. Type BX cable shall not be used.

#### 7.3.4.10 Control and Signal Wiring

Control and signal wire shall be designed as a single continuous strand from panel to device. If this cannot be performed, the two wires must be joined using a terminal block housed in a junction box that provides appropriate protection from physical damage and signal interference.

### **7.3.5 Raceway**

#### **7.3.5.1 General**

All wiring shall be run in conduit, surface metal raceway, or cable tray. The use of surface metal raceway shall be limited to renovation projects requiring horizontal distribution of electrical cabling in computer rooms and research laboratories, and shall require prior approval from VMI Physical Plant. The pre-existence of surface mounted raceway does not constitute permission to add surface mounted raceway.

#### **7.3.5.2 Minimum Size**

Minimum conduit size shall be  $\frac{3}{4}$ ".

#### **7.3.5.3 Indoor Applications**

For indoor applications, use Electric Metallic Tube (EMT), Intermediate Metal Conduit (IMC), or Rigid Metal Conduit (RMC). The use of EMT is limited to sizes 4 inches and smaller, and EMT shall not be used in floor slabs.

#### **7.3.5.4 Outdoor Applications**

For outdoor applications, use galvanized steel RMC where exposed and Schedule 40 PVC Rigid Non-metallic Conduit (RNC) for underground installations or in concrete slabs. PVC conduits installed underground shall be converted to RMC at the 90° bend and straight section before extending above grade. This applies to areas where the conduit is exposed and subject to abuse.

#### **7.3.5.5 Flexible Conduit**

Flexible Metal Conduit (FMC) and Liquid-tight Flexible Metal Conduit (LFMC) not exceeding 6' in length shall be used only for connections to lighting fixtures and motors or equipment that is subject to movement or vibrations. Exceptions or additional applications of FMC and LFMC require prior approval from VMI Physical Plant.

#### **7.3.5.6 Finished Areas**

All conduit shall be concealed in finished areas. Conduit above the ceiling shall be neatly attached to or supported from the building structure above.

#### **7.3.5.7 Mechanical and Electrical Spaces**

Conduit may be run exposed in all spaces used only to house mechanical and electrical equipment.

#### **7.3.5.8 Empty Conduits**

All empty conduits shall have a 65-lb test polymer (or equivalent) pull string tied off at both ends.

#### **7.3.5.9 Underground Raceway – Power**

Secondary service conductors and other underground feeders shall be run in concrete encased ductbanks. The ductbanks shall be constructed as follows:

- Reinforcing shall be provided for large and/or lengthy runs or where ductbanks cross under main roadways or are subject to shear forces.

- Shall include spare ducts for future use.
- Top of ductbank shall be a minimum of 24" below finished grade unless specifically approved by VMI and in accordance with the NEC.
- Shall slope to drain to prevent accumulation of water in the ductbank, and shall not have any low points.
- A metal-backed utility marker tape shall be buried 12" above each ductbank.
- A mandrel shall be pulled through all ducts prior to cable installation.
- Concrete for ductbanks shall have a minimum compressive strength of 3,000 psi at 28 days, meeting requirements of ACI 318 and ACI 301.

When providing ductbanks and manholes for primary feeders, consult with Dominion for utility specific guidelines and standards.

#### **7.3.5.10 Underground Raceway – Lighting**

Underground lighting conductors shall be direct buried in Schedule 40 PVC rigid non-metallic conduit.

### **7.3.6 General Lighting**

#### **7.3.6.1 Technology**

All lighting fixtures (interior and exterior) shall be light-emitting diode (LED) type, unless otherwise approved by VMI Physical Plant. LED drivers shall be capable of 120-277V input voltage.

#### **7.3.6.2 Access**

Accessibility and maintenance shall be considered when specifying lighting fixtures and their placement.

#### **7.3.6.3 Availability**

Selected lighting fixtures shall be readily available from multiple manufacturers. No lighting fixtures shall be specified for which the manufacturer will require a minimum order for the purchase of replacements. Non-catalog and custom lighting fixtures shall not be used unless economically justified and approved by VMI Physical Plant.

#### **7.3.6.4 Warranty**

The warranty of all LED products shall be five years minimum for both LED models and drivers.

#### **7.3.6.5 Calculations**

Foot-candle (fc) calculations for normal and emergency modes shall be submitted and shown on the drawings at the preliminary design submission. Lighting levels shall comply with the recommended fc levels found in The Lighting Handbook (IES), most current edition. Apply other IES Recommended Practices based on location and use. Submit fixture spec sheets of all proposed fixtures at the preliminary design submission. Submit any revised or added fixture spec sheets with the subsequent design submissions.

### **7.3.7 Interior Lighting Systems**

#### **7.3.7.1 Lighting Fixtures**

Interior lighting fixtures for general applications shall have a Correlated Color Temperature (CCT) of 4000k, and a minimum Color Rendering Index (CRI) of 80. LED drivers shall be 0-10V dimmable. Specialized applications may require different color temperatures or CRI values per VMI instruction.

#### **7.3.7.2 Lighting Controls**

Consult with VMI Physical Plant for lighting controls, including occupancy sensing, scene control, and dimming. Many spaces may require specific controls and schemes (e.g. offices, classrooms, conference rooms, laboratories, hallways and stairwells, bathrooms, support spaces, night lighting, and emergency egress). Controls shall account for safety and convenience, while also meeting the minimum energy code requirements enforced by the state of Virginia. Approved manufacturers for lighting control products include:

- Hubbell / UNENCO
- Acuity / Lithonia Lighting
- Lutron

#### **7.3.7.3 Emergency Lighting**

Emergency lighting systems shall be designed to meet the requirements of NFPA 101, and emergency lighting fixtures shall be UL 924 listed. The following post specific requirements also apply:

- Exit signs shall be LED with diffused lenses. Only red lettered exit signs will be used.
- Emergency egress lighting shall contain integrated batteries. Power Sentry Constant Power Emergency Drives are approved for use.
- Two emergency “bug eye” lights with integral battery shall be installed in every mechanical room.

#### **7.3.7.4 Mechanical and Electrical Spaces**

For safety reasons, lighting fixtures shall be located at or around equipment so that maintenance personnel will not obscure the required illumination.

### **7.3.8 Exterior Lighting Systems**

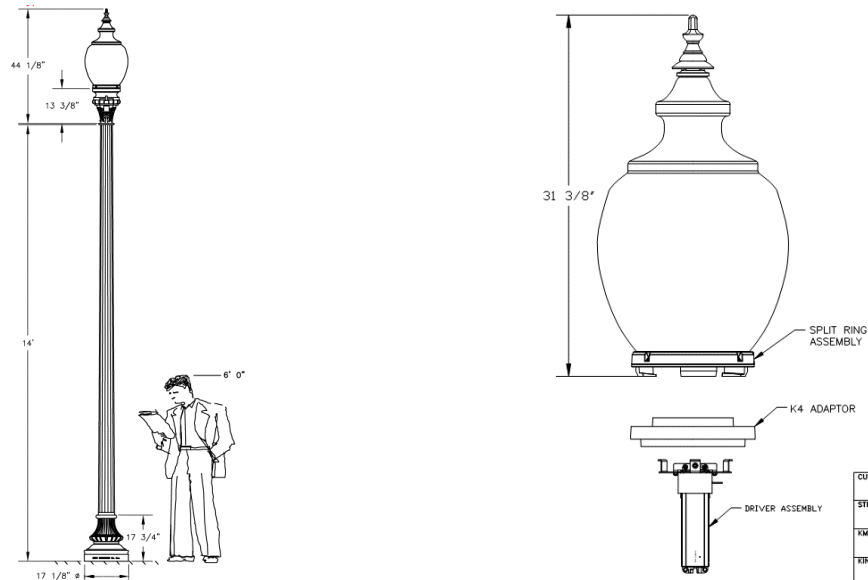
#### **7.3.8.1 General**

Discuss site lighting design and lighting fixture selections with VMI. Efforts should be made to make aesthetics of existing post lighting in coordination with VMI. Lighting along Main Street shall be coordinated with the City of Lexington.

#### **7.3.8.2 Post Top Luminaires**

The VMI post has standardized on decorative post top luminaires with a historical acorn shape. The luminaires shall have a Correlated Color Temperature (CCT) of 3000k and a minimum Color Rendering Index (CRI) of 80. Post top luminaires shall be mounted on 14’ decorative poles that are fluted and tapered. All poles are cast and formed aluminum and 4-1/2” in diameter at the top. An optional 15A/120V GFI Duplex Receptacle with weatherproof cover plate may be specified depending on the location of the pole.





### 7.3.8.3 Area Luminaires

Area luminaires used in parking and other approved areas shall have a Correlated Color Temperature (CCT) of 3000k and a minimum Color Rendering Index (CRI) of 80. Area luminaires shall be mounted on 30' round general-purpose light poles. All poles are one-piece extruded aluminum alloy, and 6" in diameter.

### 7.3.8.4 Control

Exterior lighting shall be controlled using photocells.

### 7.3.8.5 Finish

Luminaire fixtures and poles shall be painted Sherwin Williams Java color.

### 7.3.8.6 Identification

Exterior lighting fixtures/poles shall be identified with 2" high vinyl digits installed 18" above base on side towards roadway or sidewalk.

### 7.3.8.7 Building Mounted Lighting

Building mounted lights shall be provided at exit discharges and service areas. Do not recess fixtures into stucco.

## 7.3.9 Emergency and Standby Generators

### 7.3.9.1 General

If providing a generator, consult with VMI Physical Plant about back-up power needs beyond life-safety.

### 7.3.9.2 Fuel

Generators shall run on diesel fuel oil and be equipped with a double-wall UL 142 listed base tank. The emergency power supply shall be available for operation of the rated loads for a minimum of 24 hours without refueling.

#### **7.3.9.3 Enclosure**

Provide sound attenuated enclosures on all enclosed machines. If the generator has louvered openings with control dampers for intake and exhaust, they must be fail open and powered close. The A/E shall determine if the assembly needs to be Seismic Certified, and shall obtain concurrence from the VMI Physical Plant.

#### **7.3.9.4 Performance**

Generator must be available to accept load within 10 seconds of failure of the normal power supply.

#### **7.3.9.5 Remote Control and Monitoring**

Generator controllers and automatic transfer switch controllers shall interface with the BAS system using LonTalk, BACnet, or Modbus protocol. All generator and transfer switches will have remote start/stop and monitoring capability connected to the campus BAS. The installation shall provide for remote monitoring of the generator's fuel tank level and trouble alarms.

#### **7.3.9.6 Load Bank Connection**

Provide an external NEMA 4X load bank / tap cabinet for all installations that can connect to a temporary remote generator set, or a load bank to test the existing installed generator set.

#### **7.3.9.7 Location**

Generators shall not be located near any fresh air intakes.

#### **7.3.9.8 Warranty**

The warranty of all generators shall be two years minimum.

#### **7.3.9.9 Manufacturers**

Generators shall be by the following manufacturers:

- Caterpillar (CAT) Electric Power Division
- Cummins Power Generation
- Generac Power Systems
- KOHLER Power Systems

### **7.3.10 Motors and Controls**

#### **7.3.10.1 Motor Specifications**

All motors shall have the following specifications:

- Motors of ¾ horsepower and larger shall be 3-phase, using the highest available and appropriate voltage.
- Motors shall be equipped with permanently lubricated bearings.
- Motors shall be NEMA Premium Efficiency type, complying with the requirements of the latest edition of NEMA MG 1, with a service factor of 1.1 or better. Motors between 1 and 200 hp shall exceed those standards where possible and economically justified.
- Motors shall be rated for inverter duty.
- Motors shall be housed in a TEFC enclosure. ODP motors are not acceptable.

#### **7.3.10.2 Disconnects**

A lockable disconnecting means shall be provided within sight from the motor location. All disconnecting means shall be clearly marked to identify the motor that the disconnect serves.

#### **7.3.10.3 Motor Controllers**

All motors, except light-duty fractional horsepower motors, shall be provided with a motor controller. Controller shall provide under-voltage protection when used with momentary contact control devices and under-voltage release when used with maintained contact control devices. Controllers shall also provide phase-loss (single phasing) protection.

#### **7.3.10.4 Variable Frequency Drives (VFDs)**

VFDs shall be considered for all motors five horsepower and above, and have the following features:

- VFDs shall be able to communicate with Building Automation System (BAS) controls, through LonTalk, BACnet, or Modbus communications protocol.
- VFDs shall be pulse width modulated (PVM) type using IGBT technology.
- VFDs shall be provided with by-pass isolation switches.
- VFDs shall be minimum 12 pulse for higher than 60 HP and minimum 6 pulse for less than 60 HP.

#### **7.3.10.5 Harmonics**

Where multiple VFDs are fed from the same panelboard or MCC, the contractor shall provide documentation or a harmonic analysis to show compliance with IEEE 519 at the point of common coupling with the utility. Installations not meeting the requirements of IEEE 519 shall be equipped with input line filters that bring the installation into compliance. Include documentation or analysis with drive submittals.

#### **7.3.10.6 Manufacturers**

Motor control equipment shall be by the following manufacturers:

- Allen-Bradley
- Siemens / Furnas
- Schneider Electric / Square D

#### **7.3.10.7 Lightning Protection**

#### **7.3.10.8 Evaluation**

For new facilities and roof replacements, the A/E shall evaluate the building to determine if a lightning protection system is required per NFPA 780. Documentation of the evaluation shall be made available upon request.

#### **7.3.10.9 Inspection**

The installation contractor shall provide a third party master label inspection to VMI Physical Plant prior to project close out. Planning and coordination of inspections shall be conducted during the design phase, and shall be coordinate with Physical Plant.

## 7.4 PLUMBING

### 7.4.1 Water Coolers

Elkay is the preferred manufacturer for water coolers.

Water coolers shall be recessed in walls when possible.

Water coolers shall be provided with bottle fillers.

### 7.4.2 Ice Machines

Ice machines shall be air cooled only.

### 7.4.3 Greywater Systems

Greywater systems shall be considered when appropriate.

### 7.4.4 Domestic Water Heaters

The following priority of energy sources shall be considered for all new domestic water heaters:

1. Post-wide steam
2. Natural gas
3. Electric

The preferred standard for domestic water heaters is semi-instantaneous heaters utilizing post steam, equipped with clean-in-place (CIP) systems, and paired with storage tank(s). The preferred manufacturer is Patterson Kelly.

A.O. Smith is the preferred manufacturer for electric tank water heaters.

Gas-fired water heaters shall be the condensing type. Non-condensing, atmospheric water heaters shall not be installed.

### 7.4.5 Piping, Fittings, & Insulation

Copper is the preferred pipe material for domestic water. Pressure-sealed joints are the preferred joint construction method and shall be used unless otherwise approved.

The basis of design for sanitary piping shall be PVC for below grade lines and cast iron for above grade lines.

All floor drains shall be equipped with a trap primer insert.

Exterior wall hydrants (hose-bibs) shall be freeze-proof, equipped with integral backflow preventers and automatic draining, and have a square key lock. Exterior wall hydrants shall be provided on every side of a building spaced no further than 100-feet.

Interior hose-bibs shall be equipped with a square key lock. All multi-user restrooms shall be provided with at least one hose-bib.

Mechanical rooms shall be provided with a minimum of one hose-bib and one floor drain.

All new water services provided on post shall be equipped with a pressure regulating device.

The preferred insulation materials for domestic water are elastomeric and fiberglass.

#### 7.4.6 Fixtures

The following manufacturers are preferred for fixtures:

- Zurn
- Sloan

All lavatories shall be vitreous china and wall/counter mounted unless otherwise approved by VMI.

All water closets and urinals shall be wall hung unless otherwise approved by VMI.

Automatic flush valves shall be utilized for all water closets and urinals. Automatic flush valves shall be hard wired. Battery operated automatic flush valves shall not be used unless approved.

#### 7.4.7 Valves

All ball valves shall be full port.

Any valve 2-inches and larger located behind concealed walls or ceilings shall be accessible by an access panel. The minimum size of the access panel shall be 24x24-inches.

Shutoff valves shall be provided at the following locations at a minimum: take-offs from mains (vertical risers or horizontal mains) and as practically close to every end use.

#### 7.4.8 Identification

Identification of piping and ductwork shall adhere to ANSI/ASME standard A13.1.

Valve tags shall be of brass construction with black depressed lettering measuring ½-inch minimum. Tags shall be secured with brass wire-link chains.

Pipe labels shall be pretensioned semi-rigid plastic formed to cover the full circumference of the pipe and fastened around the pipe with straps. The use of adhesive stickers for pipe labeling is not allowed. Pipe labels shall include service identification and service flow arrows. Pipe labels shall be provided in visible locations, every 25-feet at minimum, on both sides of every wall/floor/ceiling penetration, and at every equipment connection.

Consult with Physical Plant staff for latest tagging scheme standard.

### 7.5 CONTROLS

#### 7.5.1 Building Automation Systems (BAS)

Virginia Military Institute operates a BACnet Honeywell Tridium N4 system as the primary BAS front-end for post. All new controls installations are preferred to utilize Honeywell Tridium products and shall be fully integrated into the post-wide BAS system via the existing N4 server.

Refer to the BAS guide specification in the Appendix: 230923 Direct Digital Control (DDC) System for HVAC. This guide specification shall serve as a reference and be fully updated and completed to adhere to project specific requirements.

All field devices shall be native BACNet for full compatibility with the Tridium N4 front end system. Specifications shall require full read/write integration between equipment and field devices to the front end system.

The preferred standard thermostat for post is a Honeywell TR-42 or equal. The preferred thermostat for common areas is a Honeywell TR-21 or equal.

All new BAS controls installations shall adhere to the VMI graphics standard. Designers shall incorporate the standard and requirements for collaboration with VMI into project specifications. Contact the Physical Plant for documentation on the current standard.

All control cabinets shall be powered from an individual circuit with no other loads. Control cabinets shall have at least one 110V power outlet within the enclosure.

Occupancy sensors shall be utilized for HVAC. Sensors shall be ceiling mounted and interface with the BAS.

## **7.6 TECHNOLOGY SYSTEMS**

### **7.6.1 General**

This document is intended to provide general guidelines and reference information for the design of new and renovated VMI buildings and structures. This document shall not take precedence over the local authority having jurisdiction for the area or locale(s) within which the work is performed. Any omission of or lack of reference to local or appropriate laws made by this document shall not relieve the architect or engineer of their obligation to meet such laws.

#### **7.6.1.1 Building Entrance**

Building entry shall consist of a minimum of (4) 4"sch40 PVC conduits from the building Main Distribution Frame (MDF) into the utility tunnel or manhole specified by VMI POC. Manhole and conduit placement shall be coordinated with VMI POC to determine the best location to connect with our existing infrastructure and network. Conduits shall enter MDF within 4" of a corner.

#### **7.6.1.2 Work Areas**

There shall be at least one telecommunication room or equipment room per floor. Multiple rooms are required if the cable length between the telecommunication room and the telecommunications outlet location, including slack, exceeds 295 ft. If the usable floor space to be served exceeds 10,000 ft<sup>2</sup>, consider additional telecommunication rooms. For telecommunication rooms that serve areas with an office density of less than one work area per 100 ft<sup>2</sup> of usable floor space, a telecommunication room may serve larger areas, provided the horizontal cable length requirements are met.

#### **7.6.1.3 Outlet Boxes**

Outlet boxes for telecommunications work areas shall be mounted at standard outlet mounting height, matching electrical power outlets. Typically this is 18" above finished floor to center of box. The architect must specify the color of outlet plate for electrical and data faceplate trim-outs. Technology design will match the color of plate specified for the electrical. This is to ensure that the electrical and datacom trimout matches. Non-standard decorative or specialty boxes and plates, required for either floor or wall; i.e., brass, wood, etc. shall contain all of the necessary fittings to bring the telecom outlet box to standard size and fittings and be included in the electrical contract. Items such as round floor boxes, furniture boxes and other non-standard items, that cannot house a standard single gang faceplate, must be retrofitted as a part of the electrical contract and brought in to standard size and conformity. Minimum of two (2) 4"x4" flush mount outlet boxes shall be installed in each work area. Outlets shall be installed on opposing walls from each other. Outlet locations shall be verified and

approved by the VMI POC at the preliminary plan phase. The VMI POC shall coordinate and confirm this process. Each work area outlet shall have a single gang plaster ring installed to accommodate the installation of a standard single gang faceplate. Outlet boxes shall also be installed as required for alarm, card readers, wireless access points, emergency phones, elevators and other special use circuits. Outlet boxes intended for use with low-voltage cabling (telecommunications, CATV, etc.) shall not host electrical power receptacles or power wiring. "Combo boxes" (divided, multi-gang device boxes for power and data behind a single faceplate) are not permitted.

#### **7.6.1.4 Floor Boxes**

Device boxes shall not be mounted in the floor (i.e. "floor boxes") except where no suitable alternative exists. If device boxes must be mounted in the floor, each device box shall be served with its own individual conduit – floor boxes shall not be "daisy-chained" together. Power outlets may be combined with telecommunications cabling in floor boxes if the power wiring is routed to the floor boxes separately from the telecommunications cabling, and if the floor box provides for metallic barrier segregation of the power and telecommunications cabling within the box. In many cases, floor boxes will be intended to host audio/visual cabling in addition to telecommunications and power. In such cases, coordinate with the audio/visual designer to achieve both telecommunications and audio/visual objectives. The Designer shall review with VMI POC on the selection of floor box type or poke- thru for each application.

#### **7.6.1.5 Grounding**

Grounding shall be provided in accordance with NFPA 70, Article 250, Article 800 and TIA/EIA 607. There must be a grounding bus bar available for each MDF and IDF that is electrically connected via a proper sized copper conductor to the Building Grounding Electrode. The Telecommunications Main Grounding Busbar (TMGB) will be installed typically in the MDF. Each telecom room will have a Telecommunication Grounding Busbar (TGB) requiring a grounding plate that is bonded to building ground and the building electrical ground. All Telecommunications rooms shall be connected and bonded to a common ground via a Telecommunications Bonding Backbone (TBB). A minimum #6AWG shall be used for the grounding back bone. Following EIA/TIA-607 - A #6AWG ground and ground bus bar shall be provided to the room and installed on the plywood backboard. This ground busbar shall be a pre-drilled copper busbar provided with standard NEMA bolt hole sizing and spacing. Each shall be bonded to building ground at the electrical service entrance equipment for the building. Cable tray shall be bonded and grounding to the TBB. Plywood shall be equipped with an AC grade or better, void-free plywood backboard (8 ft) high with a minimum thickness of (0.75 in), securely fastened with the grade C surface facing the supporting wall.

#### **7.6.2 A/E Scope**

A/E Group to offer technology infrastructure, audiovisual, security, and data center consulting and design services. A/E firm capabilities needs to improve project coordination, safeguarding integration between technologies and building systems during the course of the project. Provide organized technology system designs with associated infrastructure systems including mechanical and electrical, delivering buildable project-specific solutions. VMI POC to provide distinctive requirements of each project, and A/E firm produce client-specific designs. This methodology merges the best of evolving technologies with a responsible design philosophy, balancing performance and cost. A/E firm to have experience in state-of-the-art technology system designers in commercial, academic, government and healthcare industries. A/E design services that need to be included are Audiovisual, Security System designs, Technology Infrastructure.

The A/E firm needs to provide a design that does the following design of our systems:

- Accomplishes our goals
- Resolves our problems
- Maximizes performance
- Diminishes cost
- Meets all standards and codes list below
- Delivers flexibility and expandability
- Simplifies management and maintenance

From beginning to completion, the design team needs to assist through every phase of construction.

- Planning
- Design & Engineering
- Construction
- Project Management

Planning communication systems begins at the same time we begin planning the rest of our new office, new building, or commercial space. A/E consultants need to be able to walk through all the requirements, codes and systems with it.

Design and Engineering project needs to be broken down into individual disciplines and a complete set of drawings is prepared for each system throughout the various stages of the project. This will give us the detail we need to make sure the construction process is thorough and accurate. This will also prevent costly surprises during construction for things that were not considered during the planning phase and thereby left out of the overall design and cost estimates.

A/E firms project management and design team needs to provide a detailed set of drawings for every component so we will know what to expect during construction. Need access to up to date drawings, easily accessible from anywhere to help avoid confusion and costly mistakes made during the construction process.

A/E design needs to include drawings and cost estimates for:

- Outside Plant design and specification
- Floor Plans that show locations of network components such as telephones and network outlets
- Telecom Entrance Facilities
- Telecommunication Rooms
- Backbone and Riser Diagrams of low voltage cabling systems
- Complete Passive Horizontal Structured cabling systems which includes racks, patch panels, wire management, cabling support ladder rack system, grounding and bonding of all metallic components.
- Design pathways and spaces for Wireless Access Points
- Design pathways and spaces for Security
- Design pathways and spaces for Emergency Notification, Paging and Music
- Provide design solutions for Cable Television and CCTV
- Design pathways and spaces for Access Controls
- Design Audio visual infrastructure solutions
- New and existing system documentation
- Cable System and Vendor selection



A/E firm to provide drawings for data/phone (network) structured cabling system, including but not necessarily limited to cabling (copper and optical fiber), terminations, racks, patch panels, faceplates, jacks, patch cords, cable management, labeling . All switches UPS's and other equipment not mentioned shall be furnished and installed by the VMI POC. All patch through cables from patch panel to switch shall be provided by VMI POC. However a schedule will be provided by the A/E firm that shows the details of all cabling and where its end point shall be located for patching. All WAP's (wireless access points) and associated faceplates shall be furnished by the VMI POC. A/E firm to include WAP pathways in their drawing sets.

A/E firm to provide pathways and layout for audio/video (A/V or AV, media/technical production) structured cabling system, including but not necessarily limited to cabling, labeling, faceplates, terminations at the user outlet end, projector mounts/plates and TV mounts. Projectors, (TV's, lectern umbilical's, speakers, racks, head-end equipment, terminations at the head-end/racks, and testing shall be provided by the VMI POC).

A/E firm to provide design of access control (IDS or CCTV) structured cabling system, including cabling and labeling. All terminations, testing, control panels and user-end devices shall be furnished and installed by the VMI POC.

A/E firm to provide IT series drawings for rough-in of conduits, outlets. Provide drawings for cabling support such as cable tray, runway ladder rack systems, jhooks. Provide detailed grounding and bonding system that will safeguard equipment and personal. All materials shall be provided by the VMI POC.

A/E firm to provide careful coordination with all trades and VMI POC is required for all aspects of the work.

A/E firm design will follow the following standards set forth below.

#### *7.6.2.1 Quality Assurance*

The following standards must be adhered to for the data/phone structured cabling system:

ANSI/TIA-568-C.0	Generic Telecommunications Cabling for Customer Premises, Feb. 2009
ANSI/TIA-568-C.1	Commercial Building Telecommunications Cabling Standard, Feb. 2009
ANSI/TIA-568-C.2	Balanced Twisted-Pair Telecommunications Cabling and Component Standards, Aug. 2009
ANSI/TIA-568-C.3	Optical Fiber Cabling Components Standard, June 2008
TIA/EIA-569-C	Commercial Building Standard for Telecommunications Pathways and Spaces, May 3, 2012
TIA-606-B	Administration Standard for Commercial Telecommunications Infrastructure, June 22, 2012
TIA/EIA TSB-67	Transmission Performance Specifications for UTP Cabling
TIA/EIA 568-A-1	Propagation Delay and Delay Skew for 100 Ohm 4-pair Cable
TIA/EIA 568-B.2.1	Category 6 Final Draft
TIA/EIA-607	Commercial Building Grounding/Bonding Requirements
NFPA-70	National Electrical Code
NFPA-75	Standard for the Fire Protection of Information Technology Equipment
ANSI/IEEE C-2	National Electrical Safety Code
BICSI	Telecommunications Distribution Methods Manual 13th Edition

A/E firm shall provide a data/phone structured cabling system that shall follow ANSI/TIA and BICSI standards. The cabling system design must conform to the current issue of industry standard ANSI/TIA/EIA-568; all performance requirements of this document must be followed.

#### *7.6.2.2 Various Requirements*

Design team shall work closely with and under the direction of the VMI POC, and shall report any site issues during construction. Provide weekly updates to the VMI POC's project manager as to the progress of the cabling design. Acceptance of all deliverables shall reside with the VMI POC's project manager; this person shall either sign off on (approve) the documentation submitted, or shall reply in writing to the design team explaining what tasks must still be accomplished per the contract documents. All designers on the job site shall submit proper forms through the VMI POCs University Access Control/Card Services for clearance and access badges. Coordinate with the VMI POC for requirements regarding personal protective equipment while on the job site.

#### *7.6.2.3 Cleaning*

Design team shall coordinate with VMI POC in drawing package of cleaning all Data (Network & Media) Rooms/Closets prior to installing any equipment/gear. Verbiage to be added in design documents to ensure the contractor or VMI POC follow the guidelines set forth below.

- All conduits penetrating floors, walls, or ceiling requiring fire rated/non-fire rated caulking shall be completed prior to cleaning.
- All light fixtures shall be installed, lamped, working, provided with wire guards or lens, and cleaned.
- Floors shall be painted with a low static gray epoxy paint and cleaned.
- Rooms/Closets shall be cleaned of construction dust, dirt, debris, and construction materials
- All sprinkler heads shall be provided with protective sprinkler head wire cages, provided and installed by sprinkler contractor.

#### *7.6.2.4 Completion Documents*

A/E firm shall provide the VMI POC with as-built, marked up copy of all drawings once the project is completed. When the work on the entire project has been completed and is ready for final review, a visit shall be made by the design team on site with VMI POC. At that time, all requirements of the contract shall be demonstrated to be fully completed and that the design has been adjusted and complete in accordance therein. The A/E firm shall provide the VMI POC a written guarantee or warranty for the entire work of their design against defective materials, workmanship and performance for a period of at least one year from the date of acceptance of the design. The A/E firm hereby agrees to furnish, without cost to VMI POC, all transportation, both ways, design changes which are found to be in complete during the guarantee period. The standard warranty of the design shall be deemed acceptable, provided it meets or exceeds these requirements.

Upon completion of the project and before sign-off, A/E firm shall provide the following items to the VMI POC:

- Revit, Cad and PDF as-built (record) floor plans showing IT room locations, outlet/jack locations along with the IT room that serves each outlet, labeling scheme, cable pathways, floor numbers,

and building address. Also include jack types, fiber optic cable lengths and any other information deemed to be useful. For each change reflected on the as-built drawings, the Change Order Request number shall be shown.

- A Project Closure Report for review and approval
- Completed Project Requirements Checklist from VMI POC showing that all project tasks in these specifications and drawings have been completed, for review and approval
- Written status at sign-off meeting
- The format(s) for all documentation shall be as determined by the VMI POC. Provide all documentation in hard copy and in electronic format.

### 7.6.3 Communication Raceways

Raceways: See IT series of drawings for which raceways are to be provided by Division 26 and which are to be provided by Division 27 – use these raceways and cable trays (including runway type ladder tray in IT rooms) for all cabling. Where cables leave cable tray or conduit to go to another conduit or an outlet, Division 27 shall provide J-hooks to support the cables, no more than 5 feet apart above accessible ceilings; J-hooks shall have 6" of clearance above, below and on all sides wherever possible and shall be independently supported from the wall or structure. J-hooks shall be sized for all Division 27 cabling and shall allow for 50% future expansion. Where required to meet the 50% future expansion provide double tiered J-hooks. Outlet conduits for new construction shall not be smaller than 1" in diameter unless otherwise specified. "LB's or other tight 90 degree fittings shall not be used. Conduits shall be installed at each outlet and either stubbed to above a lift out accessible ceiling or ran to a corridor or hallway. If continuous conduit is run from the outlet box, the conduit shall have no continuous sections longer than 100 feet without the placement of an appropriately sized, and easily accessible, junction box. Outlet conduits shall not be looped from one outlet to another. Outlet conduits shall not contain more than three (3) 90 degree sweeping bends. Flex-conduit shall not be used for telecommunications pathways without the written approval of the College. No more than two 90 degree bends are allowed between pull boxes. A Nylon pull line shall be installed in each conduit placed. All conduits shall contain bushings to prevent cutting or scraping of cables during installation.

#### 7.6.3.1 Buried Conduit Specifications

Contractor shall provide and install 4" schedule 40 PVC. Contractor shall ensure conduits are separated by spacers intended for the purpose. Each conduit shall slope away from the building. Conduits shall be installed so that water cannot enter the building by means of the conduits. Contractor shall install conduits on a bed of sand or fine rock dust and encase conduits in a 3" envelope of slurry or concrete with a magnetic tape installed 12" above the concrete. Provide one, nylon pull line rated for 200 pounds in each conduit. Contractor shall ensure backfill material shall be free of rock. Conduits shall be installed so the top of the concrete is minimally 24" below finished grade. Conduit runs shall not exceed 500' between pulling points. The sum of all bends between pulling points shall not exceed 180 degrees and no single bend shall be more severe than a sweep 90 degrees. Conduit penetrations into manholes or buildings shall be adequately sealed to prevent the entrance of water. The end of conduits shall be capped unless otherwise specified. Conduit runs between manholes shall consist of (4) 4" conduits unless otherwise specified. Conduit runs between a manhole and a building shall consist of (4) 4" conduits unless otherwise specified. After installation of buried conduits all disturbed areas shall be returned to their preinstallation condition. Contractor shall bore underground areas where applicable. The contractor shall be responsible for conforming to all applicable Erosion and Sediment Control Regulations. The contractor shall coordinate all work with VMI POC.

#### **7.6.3.2 Manhole Specifications**

Maintenance holes and their covers shall be appropriately sized for the application. As a guideline a contractor shall prepare area, furnish and install a load bearing pre-cast concrete manhole of 6'x8'x7'h. The manhole shall be placed on a 12" gravel base and contain a French drain or approved drainage system within the manhole. Contractor shall ensure that all joints are properly sealed to prevent entrance of water. Point of conduit entry into manhole shall be as close to a bottom location as possible. The manhole shall have a 3' diameter removable cover labeled in a way that indicates the manhole is for communications. The manhole cover shall be load bearing and suitable to withstand traffic. Contractor shall furnish and install access ladder, racking on all four sides and pulling eyes within the manhole. The manhole shall be installed so the cover is flush with existing grade. Telecommunications maintenance holes and manholes shall not be shared with electrical power distribution infrastructure. In general, powered devices should not be located in telecommunications maintenance holes and manholes.

#### **7.6.3.3 Horizontal Distribution System**

Electrical distribution shall be separated from horizontal cabling distribution by a minimum of 12 inches. Do not mix systems, such as power, communications, and data processing, in a single cable tray. Do not mix cables with separate insulation levels, such as 600, 5,000, and 15,000 V in a single cable tray. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different levels, such as 600, 5,000, and 15,000 V.

Each work area outlet shall be directly connected by a 1" conduit to the nearest Cable tray or J-hook pathway that leads back to the IDF or MDF located on the same floor. Exposed conduit is not desired and its use shall be approved by the VMI POC. All conduits shall stub-out no further than 6" into the MDF or IDF. All conduits shall be labeled with work space numbers. All horizontal conduits shall enter the MDF/IDF from an adjacent above-ceiling space, and at no point below 90" A.F.F. If conduits must enter through the MDF/IDF floor, it shall be pre-approved by the VMI POC and conduits may not exceed two (2) rows deep. Rooms may not have service fed from two different IDFs or MDFs. All junction boxes shall be installed in an accessible location even after project is complete. Junction boxes shall be covered and placed above ceiling in a public corridor. Other conduits for special circuits, sound, security, card readers, or fire alarms that must enter the MDF or IDF, shall be grouped separately from the work area outlet conduits. All above-grade telecommunications pathways shall be 1" EMT conduit with solid steel connectors. Communications floor box conduits shall run to the nearest wall with ceiling access and then to an above-ceiling junction box or pull-box, before connecting to the nearest MDF/IDF.

#### **7.6.3.4 Cable Tray**

When cable tray is to be installed, the Architect shall be responsible for coordinating the placement of cable tray with other trades. Coordinate tray locations with lighting, air-handling systems, fire sprinkling systems and all other trades. When tray is specified, the tray must be installed with a minimum of 12" clearance above the tray and a 24" minimum clearance around the tray for the installation of cable. Cabling shall be installed in "J" hooks and/or cable trays. Any methods, other than those listed above, must be approved by VMI POC. Each segment of the cable tray requires a ground conductor bonding lug. If the cable tray is broken, all sections must be bonded and grounded. Wherever cable tray passes through a wall, the wall penetration shall be finished (no sheetrock visible) and firestopped using approved fire rated device if the wall is a fire-rated wall. All edges of the tray shall be smooth and not contain barbs or rough edges that can injury to workmen or damage to cable. Wall mounted cable trays are more accessible and preferred over center or side mounted trays. When cable trays, walls and

ceilings are painted, care shall be taken to not paint the cabling. Cable manufacturers will not warrant any painted cabling. Also, paint obscures the manufacturer-printed labeling on cables.

#### **7.6.3.5 Junction Boxes**

Junction boxes shall be a minimum 4"x4". Junction boxes shall be installed as a pull point every two (2) 90 degree bends in the horizontal cabling conduits. Conduits shall be in-line or in a "straight-thru" manner. Junction boxes shall be located within a public corridor. If more than two (2) conduits are within the same area they shall be located in a larger pull box. Larger pull boxes shall not exceed 24"x24".

#### **7.6.3.6 Surface Raceway**

Surface raceway may be permissible in areas where no suitable alternatives exist. Surface raceway shall conform to bend radius requirements for the cable type being installed. Surface raceway may be either plastic or metal. Where cabling is routed through surface raceway, the designer shall verify cable dimensions and bend radius limitations with the cable manufacturer to determine whether the surface raceway will be deep enough.

#### **7.6.3.7 Sleeve**

A pathway must be provided from the MTR to reach each of the ERs. This can be accomplished by providing access between the ERs on the various floors. When this pathway is in place, cable can be placed from the MTR to IDFs located on the same floor as the MTR and passed to the other closets. Provide four (4), 4" conduit sleeves between floors when rooms are stacked on top of each other. When rooms are not stacked, provide four (4), 4" conduits between IDFs, unless otherwise specified by the customer. Sleeves must be placed between floors. There should be a minimum of four (4), 4" conduit/sleeves between stacked IDFs each should extend above the finished floor a minimum of 3" and contain bushings. Conduits should extend above the finished floor 3", contain bushings.

Wall Sleeves shall be adequately sized to accommodate immediate needs as well as future needs. A minimum of four (4), 4" conduits shall be installed at each IDF location into the corridor cable tray. A minimum of 2" shall protrude into each ceiling space. There shall be a minimum of ½" between sleeves. Sleeves must have a protective bushing at each end to prevent chaffing. Any penetration through fire-rated walls will be sealed with an Underwriters Laboratories-approved (UL) sealant and packing within sleeve, restoring the fire rated wall to its originally rated level following ASTM E 814, UL1479 and local/state building codes. All sleeves shall contain bushings to prevent cutting or scraping of cables during installation.

#### **7.6.3.8 Furniture Pathways and Spaces**

The furniture design and placement shall not cover, impede or obstruct access to telecommunications outlets, pathways or spaces whenever possible. If furniture is to be placed flush against a wall, modular furniture should not include a modesty panel that will cover the power and communications outlets. The College does not use power poles to route cabling to cubicles. Other access options are described below.

#### **7.6.4 Twisted Pair**

The data/phone horizontal copper cabling shall be plenum-rated UTP Category 6. Cable shall be General Cable GenSpeed 6000.

- All cables shall be terminated at the IT room end in a Category 6 patch panel in the VMI POC-designated network rack in the appropriate IT room with a black Category 6 8-position 568-B RJ45 female jack. Jacks shall be Panduit CJ688TPBL. Patch panels shall be Panduit CPPL48WBLY

and (if needed) Panduit CPPL24WBLY - provide quantity of patch panels as required by quantity of cable drops, and coordinate arrangement in network rack with VMI POC.

- Cables for cameras, lighting control panels, digital meters, WAP's and schedulers shall be terminated at the device end with a Category 6 8-position 568-B RJ45 male jack. Jacks shall be Panduit SP688-C.
- See drawings for user-end termination of cables being terminated in the teaching lectern wall plate.

Cables for applications not specifically mentioned above shall be terminated with a Category 6 8-position 568-B RJ45 female jack and loaded into a Mini-Com module frame (except no Mini-Com module frame for data cables serving A/V racks or for spare cables). Any unused module frame ports shall have a blank. Jacks and Mini-Com module frames shall be color gray as selected by Architect, Panduit CJ688TPIG. Blanks shall be Panduit CMBIG-X. Mini-Com module frame shall be Panduit CFG2IG (2-port module frame), or CFG4IG (4-port module frame), or CFG6IG (6-port module frame). Faceplates shall be stainless steel Mulberry 9740X SS GFI, "X" is the # of the gang plate.

- Where an outlet has only one cable (including media DM cables where indicated for TV's), provide a two-port module frame. Where an outlet has two or three cables (including media DM cables where indicated for TV's), provide a four-port module frame. Where an outlet has four or more cables (including media DM cables where indicated for TV's), provide a six-port module frame.
- Instead of the stainless steel faceplates specified above, cables for floor boxes and poke-thru devices shall have a mounting plate that mates and matches with what Division 26 is providing for the communications compartment, which is a Decorative Style/GFCI type mounting plate, and that maintains the PanGen 25-year warranty. The Mini-Com module frame, port, and blank quantities in the mounting plates shall match what is specified above (taking into account DM cables being pulled to the floor box/poke-thru).

All cables on the service loop for the user/device end (all plenum-rated) shall be secured and dressed with, ty-wraps and/or zip-ties. All cables in network and A/V closets for all network and media racks shall be secured only with Velcro. All cables shall be labeled at both ends, in compliance with the labeling standards later in this guide.

The data/phone patch cords at the IT room end shall be Category 6 UTP (color coded in quantities as directed by VMI POC in green, yellow, blue, black, violet, orange, red and white), shall have a male RJ45 jack on each end, and shall be of appropriate length (but minimum 3 feet) – provide one (1) for each terminated cable. Patch cords shall go from the patch panels to the VMI POC-furnished VMI POC-installed switches. Patch cords shall be Panduit UTP28SP#XX, where # is the length in feet and XX is the color.

The data/phone patch cords at the outlet (user) end shall be Category 6 UTP (green color), shall have a male RJ45 jack on each end, and shall be 7 feet in length – provide one (1) for each data/phone drop that has a female termination on the user end (except not for spare cables). Patch cords shall be Panduit UTPSP7GRY.

All male-terminated cables shall have sufficient length to plug into the VMI POC's user-end device, plus a 10-foot service loop for data/phone cables and a 10-foot service loop for A/V cables.

#### 7.6.4.1 Data/Phone (Network) Structured Cabling System

Each network rack shown in IT rooms shall be a two-post 19"W x 84"H open-framed communications rack bolted to the floor. Each of these racks shall have patch panels, double-sided 6" wide vertical cable managers on each side of the rack, double-sided horizontal cable managers above and below each patch panel, and front-only horizontal cable managers between switches. Each rack shall be grounded as indicated on the IT series of drawings. Racks shall be Panduit CMR19X84. Vertical cable managers shall be Panduit WMPVHC45E. Horizontal cable managers shall be Panduit WMPH2E for patch panel side and Panduit WMPHF2E for switch side between switches. Provide 6" cable tray stand-off kits on top of the network and media racks in all the data/IT closets, Cooper B-Line SB227R6.

Each IT room shall have an 18" wide black ladder runway type tray system, with both horizontal and wall bracket-mounted vertical components as indicated on the IT series of drawings. All ladder tray shall be grounded as indicated on E002 drawing. Ladder tray shall be Hubbell HLSXX18B, where XX is the straight section length; also provide Hubbell HLMPK19 mounting plates for racks, Hubbell HLVWBK vertical wall brackets, Hubbell HLX1518 wall angle supports, Hubbell HLTK T-junction splice kits, Hubbell HLBSK butt splice kits, and appropriate ceiling mounting hardware

Note that all conduit sleeves in IT room fire-rated walls and floors are pre-made Hilti firestop sleeve provided by Division 26, unless specifically indicated otherwise.

#### 7.6.5 Coaxial

Coaxial cabling for television is typically only required for residential facilities. Both telecommunications cabling and CATV coaxial cabling are permitted to be terminated in a shared device box. VMI POC no longer provides coaxial cabling for television services in academic buildings without unique requirements for such services.

#### 7.6.6 Optical Fiber

The data/phone backbone cabling shall be hybrid single-mode\multi-mode plenum-rated fiber optic cable from the MDF to each IDF in this building as indicated on the IT series of drawings ("star" topology from main IT room), with number of strands as indicated on the IT series of drawings. There shall also be a hybrid single-mode\multi-mode fiber optic backbone cabling to other buildings as indicated on the IT series of drawings, as well as hybrid single-mode\multimode fiber optic backbone cabling connecting the IT rooms on each floor as indicated on the IT series of drawings for redundancy. Terminate each cable in its respective network rack(s) with pre-terminated fusion splice pigtails with LC-style ends. Also provide all fiber optic patch cords, adapter panels, etc. necessary for a complete installation in each rack. Innerduct shall be used to route fiber optic backbone inside the building and a max cell type product or equivalent should be used to route the fiber in conduits outside the building. Provide the following products in quantities as required for a complete installation:

- Rack Mount Fiber Enclosures (for fiber adapter panels) shall be Corning CCH-04U.
- Fiber Adapter Panels shall be Corning for singlemode CCH-CP12-24A9 and CCH-CP12-91 for multimode.
- Fiber Fan-Out Kits shall be 1 meter 12-fiber, Corning FAN-BT2-12.
- Fiber patch cords for connecting fiber between IT rooms shall be LC-to-LC 1 meter duplex single-mode and multimode. Provide these in quantities as necessary for a complete installation (but a minimum of 20).
- Fiber patch cords for VMI POC's data switches shall be LC-to-LC 3 meter duplex single-mode and multimode. Provide two (2) per VMI POC-furnished VMI POC-installed data switch – coordinate with VMI POC for current switch count.

- Fiber Pigtails shall be 3 meter 12-fiber LC pre-terminated single-mode and multimode.
- Fiber Sleeves shall be Fiber Instrument Sales F1-1002T or equivalent.
- 24-strand hybrid fiber optic cabling within the building shall be General Cable or equivalent.
- 144-strand hybrid fiber optic cabling to other buildings shall be Panduit or equivalent.
- Use Fiber Instrument Sales F1-6704 wipes and F1-000728 isopropyl alcohol for cleaning or TEC 1610-50PK or equivalent
- 288-strand hybrid fiber optic cabling rated shall be Panduit or equivalent
- Fiber connectors for the fiber backbone, patch panels, and patch cables shall all be “LC” connectors.
- Pigtailed Splice Cassette, 12 F, LC UPC duplex, single-mode and 12 F, LC UPC duplex, multimode-mode shall be Corning.
- Splice Protection, Heat Shrink Fusion Splice Protector parts, single fiber, and 60 mm long shall be Corning 2806031-01, or equivalent.

#### 7.6.7 Wireless Communication

Wireless access point location shall be determined by the VMI POC. All WAPs shall have a 4 11/16” x 4 11/16” junction box with an extension ring in order to maintain the infrastructure bend radius. All WAP boxes shall have conduits installed in accordance with outlet boxes and conduit specifications previously stated. WAPs installed in “drop-ceiling” shall be mounted not more than 12” above finished ceiling and include a single-gang plaster ring. WAPs installed in a drywall or “hard” ceiling shall have flush-mounted outlet boxes with a double-gang plaster ring. All WAP’s shall be furnished by the VMI POC and shall be installed and fully connected by the Division 27 (the VMI POC will do all start-up and programming). Carefully coordinate installation with VMI POC. Division 27 shall assist VMI POC in ensuring connectivity and functionality. Contractor shall remove the MAC address sticker label from each WAP and place it on a set of VMI POC-approved floor plans in the actual location the WAP is installed.

#### 7.6.8 Fire Alarm – Simplex Fully Addressable

VMI has standardized on Simplex fully addressable fire alarm systems for all applications. The systems are interconnected and monitored through the Simplex TrueSite workstation, which also enables mobile access to fire alarm panel status.

Mass Notification is a requirement in all academic and administrative buildings. Smaller auxiliary buildings including VMI-owned faculty and staff housing require only addressable systems without Mass Notification. The Institute has several levels of mass notification in place. A “Big Voice” system is in place for outdoor locations via high powered outdoor speakers. Indoor locations are covered by several provisions including:

- Announcements over VOIP telephone sets
- Announcements via mass notification (MN) equipped fire alarm systems or PA systems in some buildings
- Mass e-mails to vmi.edu e-mail accounts
- Mass texts to cellular users who subscribe to them voluntarily

The fire alarm systems are currently maintained under a contract with Johnson Controls (JCI), who now owns the Simplex brand. Simplex addressable fire alarm systems will be specified as single source to ensure compatibility with the TrueSite system.

In order to justify a sole-source procurement, the A/E shall complete DGS forms CO-18 (Sole Source Procurement Request) and CO-18a (Sole Source Procurement Disclosure Statement) and shall submit



these to DEB for approval at the Preliminary submittal phase. Upon approval of the CO-18, VMI shall obtain vendor quotes for the Simplex system required by the Contract Documents and shall include this cost as a line item in the Bid Form as an allowance.

#### **7.6.9 CCTV – Johnson Controls (Tyco software and American Dynamics Video Edge servers)**

The post currently has a moderate number of new (3 years or less) surveillance cameras and a current video management system consisting of hardware and software deployed throughout the post. The present mode of operation is as an investigative tool when incidents occur. There is no continuous monitoring of the system, and no data analytic software is in place to create alarms for certain pre-defined activities captured on camera. Coverage is primarily inside buildings at entrances, and exterior coverage is very light at present, with a minimal number of cameras.

VMI employs the American Dynamics (a Tyco company) “Victor” video surveillance software systems. The system consists of cameras installed in numerous buildings, each building equipped with an American Dynamics Video Edge server (Photo 3.3.2) and Network Video Recorder (NVR) to integrate its cameras. Video data for these cameras is stored locally on the server at each equipped building. The Video Edge servers are each connected to a nearby post LAN data switch to provide connectivity between all of the video servers and the master video controller located in the main data center in Nichols Engineering Building. This server acts as the master to control the cameras and to move data back and forth on the system. The video surveillance system can currently be accessed by Victor client workstations which can be network connected anywhere on the post LAN system.

#### **7.6.10 Access Control – Vanderbilt SMS Access Control Systems**

Access control is relatively robust in areas where it is fully deployed. The majority of academic buildings are fully equipped. Doors with the standard hardware packages are completely controllable from the main access control workstation (controlled by the post locksmith) and can notify the system or a user via a text or an e-mail if doors are forced or propped.

VMI runs Vanderbilt SMS access control software, Enterprise Version 6.1.0, and uses Vanderbilt access controllers and field electronic devices. The SMS system was originally developed by the Schlage lock company and was later acquired by Vanderbilt Industries.

The majority of the doors are hard-wired to local access control panels, however a minority of door locations are connected via a Panel Interface Module (PIM) that receives and transmits wireless data to the lock sets. The PIM is then connected to a standard hard-wired door controller that is connected to the post network through a data switch via IP protocol.

#### **7.6.11 Security Systems**

VMI has several locations that are equipped with security systems to detect intrusion and notify a call center if activated. Locations include, but are not limited to the Nuclear Lab, Firing Range, New Market BSHP, and Leadership Residences. These systems are stand-alone in each structure or area, and are connected to a third-party monitoring service via cellular communications.

The VMI POC will inform the A/E if a specific project or portion thereof requires the installation of a security system.

The basis of design for security systems is Bosch Inovonics EchoStream. This is a wireless security product operating on an RF communication protocol. Wired devices and sensors are interfaced using interface modules that convert the hard-wired signal to RF transmission compatible with the EchoStream protocol.

Security systems are not a sole-source justified item, so specifications may list the Bosch systems as a design basis with at least two other competitive products, but require the provided systems to possess equivalent features and quality.

## 8 EDUCATION TECHNOLOGY

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### 8.1 CLASSROOM TECHNOLOGY

#### 8.1.1 General

Certain technologies are expected by faculty members to be present in a room used to teach. Individual faculty instructions styles and technology expectations vary nearly as much as their personalities. Nevertheless, the Dean of Faculty directed the Committee on Academic Technologies (CAT) to develop a Minimum Level of Technology (MLT) standard suitable to all faculty members such that an instructor walking into any classroom at VMI has a reasonable expectation of the technology that will be available.

Between 2021-2023, the CAT worked in conjunction with the Information Technology (IT) department to develop a list of technology that all rooms must contain to meet this requirement, and then to bring these rooms to that level. The Room Technology Needed to Meet the Minimum Level of Technology description below is a summation of the effort of CAT members collecting a great deal of input from faculty across post, evaluating 117+ rooms for various levels of technology, etc.

The MLT standard will be reviewed on a 3- to 5-year cycle and recommendations to stakeholders to address the continuously evolving nature of technology in the classroom.

These future discussions will also focus on “smart” education spaces and the possibility of incorporating new technologies such as virtual reality (VR) equipment or artificial intelligence (AI) systems.

As of 2024, the standard education space does not require VR or AI equipment. However, we are currently undergoing a metered transition to begin incorporating smart touchscreen monitors where appropriate.

#### 8.1.2 Stakeholders

- Information Technology Desktop Support Manager and Director
- Committee on Academic Technologies as a liaison for the faculty
- Dean of Faculty

#### 8.1.3 Room Technology Minimum

##### 1. Projection technology

- a. Depending on room size and configuration this could be 1) a high-definition laser projector and projector screen or 2) a large touchscreen smart monitor (i.e. Newline monitors).

##### 2. Wireless casting capabilities supporting Mac's and PCs, at a minimum

- a. Any projection technology (screen or monitors) should have wireless casting, and direct port (e.g. HDMI, USB C, USB 2, etc.) connection capabilities. Note: Crestron systems meet these requirements as do touchscreen smart monitors.

##### 3. High quality stereo sound system

##### 4. Desktop PC or low form factor PC attached to a touchscreen monitor

- a. The PC must have an internet connection, keyboard, mouse, monitors, and webcam.
  - b. The low form factor PCs attached to touchscreen monitor will need a wireless keyboard and wireless mouse.
- 5. A podium with sufficient space to place paperwork.**
- 6. AV Switching equipment (i.e. Crestron systems)**
- 7. Hovercam or Elmo to project writing, or writing pad**
- 8. WiFi capabilities for a full class to be online concurrently.**
- 9. Power outlets to support 50% room capacity to be plugged in concurrently.**
- 10. Audio and video recording capabilities, to support lecture recordings (for travelling athletes or absent students) and hybrid meetings (zoom, Teams, etc.)**
  - a. At a minimum, a webcam can suffice.
  - b. A Pan-Zoom-Tilt camera is preferred.
- 11. Any usable wall space should be writable.**
  - a. Glass boards would be preferred.
  - b. High quality dry erase whiteboards would be acceptable.
- 12. Movable tables and chairs.**
- 13. Multiple concurrent workspaces are necessary (2 at minimum, 3 or more if possible). For example:**
  - a. Board + HD laser projector and projector screen
  - b. Board + HD laser projector screen + monitor
  - c. Board + monitor
  - d. Board + monitor + monitor

#### **8.1.4 Items to consider when developing a room configuration**

##### **1. The function of the room.**

- The faculty who are likely to be using the space should be consulted, in conjunction with IT personnel.
- How the room will be used to teach. For example: normal classroom environment vs specialty collaboration rooms.

##### **2. The size of the room.**

- Conference rooms will have smaller spaces to build education technology around. These should probably not have a mounted projector and projector screen. This is true even for larger board rooms like the Smith Hall Board room, while the much larger Turman room can house a projector and laser projector. Scott Shipp 420 is a good example of a preferred configuration.
  - It may make sense for small rooms to only have a monitor and writing space but it may be appropriate to include two monitors and writing space in medium-sized rooms. It may be justified in larger rooms to have a writing space, projector, and monitor.
  - Unique seminar rooms like the Large Physics Lecture room require multiple mounted projector screens and HD Laser Projectors
3. **It is crucial that a projector screen does not drop down to cover the only available writing space, thereby forcing instructors to use one or the other (or constantly raise or lower the screen) because many faculty use multiple spaces concurrently. Alternative solutions should be explored with primary users, if it is impossible to meet this requirement.**
  4. **Scheduling software will be coming online for all educational rooms to schedule classes. The software will have room classifications built in. It allows the Registrar to determine which is the best space for the faculty member teaching the class and which layout will work the best for the amount of students in the class.**

### 8.1.5 Room Configuration Examples

#### Example Preferred Teaching Room Configuration 1:

1. Touchscreen smart monitor, 1 or 2 units, with imbedded wifi connection, and also containing a low form factor PC mounted to the Newline monitor with wireless keyboard and mouse.
2. PZT camera with tracking technology and high-quality microphones mounted from ceiling.
3. Podium with Hovercam, Elmo, or writing pad
4. AV switching equipment.
5. Maximized board space; Power outlets; Wifi; movable tables and chairs; High-quality speakers

#### Example Preferred Teaching Room Configuration 2:

1. One touchscreen smart monitor with imbedded wifi connection, and containing a low form factor PC mounted to the Newline monitor with wireless keyboard and mouse.
2. One HD Laser projector and projector screen. Note: it is critical that the projector screen does not cover board space.
3. PZT camera with tracking technology and high-quality microphones mounted from ceiling.
4. AV switching equipment.

5. Podium with Hovercam, Elmo, or writing pad and PC with a keyboard, mouse, monitor, webcam, and necessary ports.
6. Maximized board space; Power outlets; Wifi; movable tables and chairs; High-quality speakers

**Example Preferred Teaching Room Configuration 3:**

1. One HD Laser projector and projector screen. Note: it is critical that the projector screen does not cover board space.
2. Podium with Hovercam, Elmo, or writing pad and PC with a keyboard, mouse, monitor, webcam, and necessary ports.
3. AV switching equipment.
4. Podium with Hovercam, Elmo, or writing pad and PC with a keyboard, mouse, monitor, webcam, and necessary ports.
5. Maximized board space; Power outlets; Wifi; movable tables and chairs; High-quality speakers

**8.1.6 Model Numbers and Current Cost of Select Equipment Preferred by IT in Spring 2024**

Item Name (Purpose)	Purpose	Manufacturer	Model Number	Current Cost	Suitable for Room Configurations [1, 2, and/or 3]
Projector	Project image from PC to projector screen	Panasonic	PT-FRZ50WU7	\$3,249.48	3
Crestron control panel	Controls PC, projector, and laptop connection, AirMedia	Crestron	HP-PS401	\$2,200.00	3
Newline Monitor	Collaboration monitor	Newline	750Q 4K LED	\$2,665.00	1 and 2
HoverCam	Used as a Webcam and ELMO	HoverCam	Solo 8 Plus	\$350.00	1, 2, and 3

### 8.1.7 Photos of select room configurations current as of Spring 2024

#### 1. Standard classroom



## 2. Auditorium style classroom





### 3. Collaboration room style classroom



## APPENDIX

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## A: SECTION 092400 - CEMENT PLASTERING

### PART 1 - GENERAL

#### 1.1 SUMMARY

##### A. Section Includes:

1. Exterior vertical plasterwork (stucco).
2. Exterior horizontal and nonvertical plasterwork (stucco).

#### 1.2 FIELD CONDITIONS

##### A. Comply with ASTM C 926 requirements. B.

##### B. Exterior Plasterwork:

1. Apply and cure plaster to prevent plaster drying out during curing period. Use procedures required by climatic conditions, including moist curing, providing coverings, and providing barriers to deflect sunlight and wind.
2. Apply plaster when ambient temperature is greater than 40 deg F (4.4 deg C).
3. Protect plaster coats from freezing for not less than 48 hours after set of plaster coat has occurred.

### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- ##### A. Fire-Resistance Ratings:
- Where indicated, provide cement plaster assemblies identical to those of assemblies tested for fire resistance according to ASTM E119 by a qualified testing agency.

#### 2.2 METAL LATH

- ##### A. Expanded-Metal Lath:
- ASTM C847, cold-rolled carbon-steel sheet with ASTM A653/A653M, G60 (Z180), hot-dip galvanized-zinc coating.

1. Recycled Content: Post-consumer recycled content plus one-half of pre-consumer recycled content not less than 25 percent.
2. Diamond-Mesh Lath: Flat or Self-furring as required, 2.5 lb/sq. yd. (1.4 kg/sq. m).

- ##### B. Paper Backing:
- FS UU-B-790a, Type I, Grade D, Style 2 vapor-permeable paper.

1. Provide paper-backed lath unless otherwise indicated at exterior locations.

## 2.3 ACCESSORIES

- A. General: Comply with ASTM C1063, and coordinate depth of trim and accessories with thicknesses and number of plaster coats required.
- B. Metal Accessories:
  - 1. Foundation Weep Screed: Fabricated from hot-dip galvanized-steel sheet, ASTM A653/A653M, G60 (Z180) zinc coating.
  - 2. Cornerite: Fabricated from metal lath with ASTM A653/A653M, G60 (Z180), hot-dip galvanized-zinc coating.
  - 3. External- (Outside-) Corner Reinforcement: Fabricated from metal lath with ASTM A653/A653M, G60 (Z180), hot-dip galvanized-zinc coating.
  - 4. Casing Beads: Fabricated from zinc; square-edged style; with expanded flanges.
  - 5. Control Joints: Fabricated from zinc; one-piece-type, folded pair of unperforated screeds in M-shaped configuration; with perforated flanges and removable protective tape on plaster face of control joint.
  - 6. Expansion Joints: Fabricated from zinc; folded pair of unperforated screeds in M-shaped configuration; with expanded flanges.
  - 7. Two-Piece Expansion Joints: Fabricated from zinc; formed to produce slip-joint and square-edged reveal that is adjustable from 1/4 to 5/8 inch (6 to 16 mm) wide; with perforated flanges.

## 2.4 MISCELLANEOUS MATERIALS

- A. Water for Mixing and Finishing Plaster: Potable and free of substances capable of affecting plaster set or of damaging plaster, lath, or accessories.
- B. Fiber for Base Coat: Alkaline-resistant glass or polypropylene fibers, 1/2 inch (13 mm) long, free of contaminants, manufactured for use in cement plaster.
- C. Bonding Compound: ASTM C932.
- D. Fasteners for Attaching Metal Lath to Substrates: ASTM C1063.
- E. Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper, not less than 0.0475-inch (1.21-mm) diameter unless otherwise indicated.

## 2.5 PLASTER MATERIALS

- A. Portland Cement: ASTM C150/C150M, Type I or Type II.
- B. Masonry Cement: ASTM C91, Type N.
- C. Lime: ASTM C206, Type S; or ASTM C207, Type S.
- D. Sand Aggregate: ASTM C897.
- E. Perlite Aggregate: ASTM C35.

- F. Sand Aggregate: ASTM C 897.
- G. Acrylic-Based Finish Coatings: Factory-mixed acrylic-emulsion coating systems formulated with colorfast mineral pigments and fine aggregates; for use over cement plaster base coats. Include manufacturer's recommended primers and sealing topcoats for acrylic-based finishes.
  - 1. Tammscoat by Euclid Chemical Company
    - a. Color: Tammscoat 747.

## 2.6 PLASTER MIXES

- A. General: Comply with ASTM C926 for applications indicated.
  - 1. Fiber Content: Add fiber to base-coat mixes after ingredients have mixed at least two minutes. Comply with fiber manufacturer's written instructions for fiber quantities in mixes, but do not exceed 1 lb of fiber/cu. yd. (0.6 kg of fiber/cu. m) of cementitious materials.
- B. Base-Coat Mixes for Use over Metal Lath: Scratch and brown coats for three-coat plasterwork as follows:
  - 1. Portland Cement Mixes:
    - a. Scratch Coat: For cementitious material, mix 1 part portland cement and 3/4 to 1-1/2 parts lime. Use 2-1/2 to 4 parts aggregate per part of cementitious material.
    - b. Brown Coat: For cementitious material, mix 1 part portland cement and **3/4 to 1-1/2** parts lime. Use 3 to 5 parts aggregate per part of cementitious material, but not less than volume of aggregate used in scratch coat.
  - 2. Masonry Cement Mixes:
    - a. Scratch Coat: Mix 1 part masonry cement and 2-1/2 to 4 parts aggregate.
    - b. Brown Coat: Mix 1 part masonry cement and 3 to 5 parts aggregate, but not less than volume of aggregate used in scratch coat.
- C. Base-Coat Mixes for Use over Unit Masonry and Concrete: Single base (scratch) coat for two-coat plasterwork on low-absorption plaster bases as follows:
  - 1. Portland Cement Mix: For cementitious material, mix 1 part portland cement and 0 to 3/4 part lime. Use 2-1/2 to 4 parts aggregate per part of cementitious material.
- D. Base-Coat Mixes for Use over Unit Masonry and Concrete: Single base (scratch) coat for two-coat plasterwork on high-absorption plaster bases as follows:
  - 1. Portland Cement Mix: For cementitious material, mix 1 part portland cement and 3/4 to 1-1/2 parts lime. Use 2-1/2 to 4 parts aggregate per part of cementitious material.
- E. Job-Mixed Finish-Coat Mixes:

1. Portland Cement Mix: For cementitious materials, mix 1 part portland cement and 1-1/2 to 2 parts lime. Use 1-1/2 to 3 parts aggregate per part of cementitious material.

## PART 3 - EXECUTION

### 3.1 INSTALLATION, GENERAL

- A. Prepare smooth, solid substrates for plaster according to ASTM C926.
- B. Fire-Resistance-Rated Assemblies: Install components according to requirements for design designations from listing organization and publication indicated on Drawings.

### 3.2 INSTALLING METAL LATH

- A. Metal Lath: Install according to ASTM C1063.

### 3.3 INSTALLING ACCESSORIES

- A. Install according to ASTM C1063 and at locations indicated on Drawings.
- B. Reinforcement for External (Outside) Corners:
  1. Install lath-type, external-corner reinforcement at exterior locations.
- C. Control Joints: Locate as approved by Owner for visual effect and as follows:
  1. As required to delineate plasterwork into areas (panels) of the following maximum sizes:
    - a. Vertical Surfaces: 144 sq. ft. (13.4 sq. m).
  2. At distances between control joints of not greater than 18 feet (5.5m) o.c.
  3. As required to delineate plasterwork into areas (panels) with length-to-width ratios of not greater than 2-1/2:1.
  4. Where control joints occur in surface of construction directly behind plaster.
  5. Where plasterwork areas change dimensions, to delineate rectangular-shaped areas (panels) and to relieve the stress that occurs at the corner formed by the dimension change.

### 3.4 PLASTER APPLICATION

- A. General: Comply with ASTM C926.
- B. Bonding Compound: Apply on cleaned and dried unit masonry and concrete substrates for direct application of plaster.
- C. Walls; Base-Coat Mixes for Use over Metal Lath: For scratch and brown coats, for three-coat plasterwork with 3/4-inch (19-mm) total thickness, as follows:
  1. Portland cement mixes.

- D. Plaster Finish Coats: Apply to provide historic finish to match existing adjacent finished areas.

### 3.5 PLASTER REPAIRS

- A. Repair or replace work to eliminate cracks, dents, blisters, buckles, crazing and check cracking, dry outs, efflorescence, sweat outs, and similar defects and where bond to substrate has failed.

### 3.6 CLEANING AND PROTECTION

- A. Remove temporary protection and enclosure of other work after plastering is complete. Promptly remove plaster from door frames, windows, and other surfaces not indicated to be plastered. Repair floors, walls, and other surfaces stained, marred, or otherwise damaged during plastering.

END OF SECTION 092400

**B: SECTION 230923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC****1.1 SYSTEM DESCRIPTION**

- A. Scope: Furnish all labor, materials and equipment necessary for a complete and operating Building Automation System (BAS), utilizing Direct Digital Controls as shown on the drawings and as described herein. Drawings are diagrammatic only. All controllers furnished in this section shall communicate on a peer-to-peer bus over an open protocol bus (Examples: LonTalk, BACnet, MODBUS).
1. The intent of this specification is to provide a system that is consistent with BAS systems throughout the owner's facilities running the Tridium Niagara 4 Framework and Honeywell WEBS-N4 Workbench software.
  2. System architecture shall fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols including, as a minimum, LonTalk, BACnet and MODBUS.
  3. System architecture shall provide secure Web access using any of the current versions of Microsoft Internet Explorer, Microsoft Edge, Mozilla Firefox, or Google Chrome browsers from any computer on the owner's LAN.
  4. All control devices furnished with this Section shall be programmable directly from the Niagara 4 Workbench embedded toolset upon completion of this project. The use of configurable or programmable controllers that require additional software tools for post-installation maintenance shall not be acceptable.
  5. The existing BAS server shall host all graphic files for the control system. All graphics and navigation schemes for this project shall match those that are on the existing campus Niagara 4 Framework server.
  6. Desktop computers including engineering/programming software to modify Operating System Server BAS programs and graphics shall be included. Desktop computers will be furnished by VMI.
  7. The Owner shall have full licensing and full access rights for all network management, operating system server, engineering and programming software required for the ongoing maintenance and operation of the BAS.
  8. OPEN NIC STATEMENTS - All Niagara 4 software licenses shall have the following NiCS: "accept.station.in=\*"; "accept.station.out=\*"and "accept.wb.in=\*"and "accept.wb.out=\*". All open NIC statements shall follow Niagara Open NIC specifications.
  9. All JACE hardware licenses and certificates shall be stored on local MicroSD memory card employing encrypted "safe boot" technology.



10. To ensure quality, any JACE 3E, 6E, or 7 hardware products used on this project shall come through the Tridium Richmond, VA shipping facility. JACE hardware products not meeting this requirement will not be allowed.
  11. Tagging conventions shall follow Project Haystack data modeling standard.
- B. All products of the BAS shall be provided with the following agency approvals. Verification that the approvals exist for all submitted products shall be provided on request, with the submittal package. Systems or products not currently offering the following approvals are not acceptable.
1. Federal Communications Commission (FCC), Rules and Regulations, Volume II -July 1986 Part 15 Class A Radio Frequency Devices.
  2. FCC, Part 15, Subpart B, Class B
  3. FCC, Part 15, Subpart C
  4. FCC, Part 15, Subpart J, Class A Computing Devices.
  5. UL 504 - Industrial Control Equipment.
  6. UL 506 - Specialty Transformers.
  7. UL 910 - Test Method for Fire and Smoke Characteristics of Electrical and Optical-Fiber Cables Used in Air-Handling Spaces.
  8. UL 916 - Energy Management Systems All.
  9. UL 1449 - Transient Voltage Suppression.
  10. Standard Test for Flame Propagation Height of Electrical and Optical - Fiber Cables Installed Vertically in Shafts.
  11. EIA/ANSI 232-E - Interface Between Data Technical Equipment and Data Circuit Terminal Equipment Employing Serial Binary Data Interchange.
  12. EIA 455 - Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Connecting and Terminating Devices.
  13. IEEE C62.41- Surge Voltages in Low-Voltage AC Power Circuits.
  14. IEEE 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
  15. NEMA 250 - Enclosures for Electrical Equipment.
  16. NEMA ICS 1 - Industrial Controls and Systems.
  17. NEMA ST 1 - Specialty Transformers.

18. NCSBC Compliance, Energy: Performance of control system shall meet or surpass the requirements of ASHRAE/IESNA 90.1-1999.
19. CE 61326.
20. C-Tick.
21. cUL.

## 1.2 SPECIFICATION NOMENCLATURE

### A. Acronyms used in this specification are as follows:

1. Actuator: Control device that opens or closes valve or damper in response to control signal.
2. AI: Analog Input.
3. AO: Analog Output.
4. Analog: Continuously variable state over stated range of values.
5. BAS: Building Automation System.
6. DDC: Direct Digital Control.
7. Discrete: Binary or digital state.
8. DI: Discrete Input.
9. DO: Discrete Output.
10. FC: Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.
11. FO: Fail open (position of control device or actuator). Device moves to open position on loss of control signal or energy source.
12. GUI: Graphical User Interface.
13. HVAC: Heating, Ventilating and Air Conditioning.
14. IDC: Interoperable Digital Controller.
15. ILC: Interoperable Lon Controller.
16. LAN: Local Area Network.
17. Modulating: Movement of a control device through an entire range of values, proportional to an infinitely variable input value.

- 18. Motorized: Control device with actuator.
- 19. NAC: Network Area Controller.
- 20. NC: Normally closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.
- 21. NO: Normally open position of switch after control signal is removed; or the open position of a controlled valve or damper after the control signal is removed; or the usual position of a manually operated valve.
- 22. OSS: Operating System Server, host for system graphics, alarms, trends, etc.
- 23. Operator: Same as actuator.
- 24. PC: Personal Computer.
- 25. Peer-to-Peer: Mode of communication between controllers in which each device connected to network has equal status and each shares its database values with all other devices connected to network.
- 26. P: Proportional control; control mode with continuous linear relationship between observed input signal and final controlled output element.
- 27. PI: Proportional-Integral control, control mode with continuous proportional output plus additional change in output based on both amount and duration of change in controller variable (reset control).
- 28. PICS: BACnet Product Interoperability Compliance Statement.
- 29. PID: Proportional-Integral-Derivative control, control mode with continuous correction of final controller output element versus input signal based on proportional error, its time history (reset) and rate at which it's changing (derivative).
- 30. Point: Analog or discrete instrument with addressable database value.
- 31. WAN: Wide Area Network.

### 1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

### 1.4 ACTION SUBMITTALS

- A. Multiple Submissions:
  - 1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.

2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

B. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
  - a. Workstations.
  - b. Printers.
  - c. Gateways.
  - d. Routers.
  - e. Protocol analyzers.
  - f. DDC controllers.
  - g. Enclosures.
  - h. Electrical power devices.
  - i. UPS units.
  - j. Accessories.
  - k. Instruments.
6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

C. Software Submittal:

1. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, and DDC controller.
2. Description and technical data of all software provided, and cross-referenced to products in which software will be installed.
3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
5. Listing and description of each engineering equation used with reference source.

6. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
7. Description of operator interface to alphanumeric and graphic programming.
8. Description of each network communication protocol.
9. Description of system database, including all data included in database, database capacity and limitations to expand database.
10. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden and system throughout.
11. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

D. Shop Drawings:

1. General Requirements:
  - a. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.
  - b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
  - c. Drawings Size: 11-inch by 17-inch or 8.5-inch by 11-inch.
2. Plan Drawings indicating the following:
  - a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork and piping.
  - b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
  - c. Each desktop workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
  - d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
  - e. Network communication cable and raceway routing.
3. Schematic drawings for each controlled HVAC system indicating the following:
  - a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
  - b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
  - c. A graphic showing location of control I/O in proper relationship to HVAC system.
  - d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
  - e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
  - f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
  - g. Narrative sequence of operation.

- h. Graphic sequence of operation, showing all inputs and output logical blocks.
4. Control panel drawings indicating the following:
  - a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
  - b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
  - c. Front, rear, and side elevations and nameplate legend.
  - d. Unique drawing for each panel.
5. DDC system network riser diagram indicating the following:
  - a. Each device connected to network with unique identification for each.
  - b. Interconnection of each different network in DDC system.
  - c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
  - d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.
6. DDC system electrical power riser diagram indicating the following:
  - a. Each point of connection to field power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
  - b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
  - c. Each product requiring power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
  - d. Power wiring type and size, race type, and size for each.
7. Monitoring and control signal diagrams indicating the following:
  - a. Control signal cable and wiring between controllers and I/O.
  - b. Point-to-point schematic wiring diagrams for each product.
  - c. Control signal tubing to sensors, switches and transmitters.
  - d. Process signal tubing to sensors, switches and transmitters.
  - e. Pneumatic main air and control signal tubing to pneumatic damper and valve actuators, pilot-positioners if applicable, and associated transducers.
8. Color graphics indicating the following:
  - a. Itemized list of color graphic displays to be provided.
  - b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
  - c. Intended operator access between related hierarchical display screens.

### E. System Description:

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
  2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
  3. System and product operation under each potential failure condition including, but not limited to, the following:
    - a. Loss of power.
    - b. Loss of network communication signal.
    - c. Loss of controller signals to inputs and outpoints.
    - d. Operator workstation failure.
    - e. Server failure.
    - f. Gateway failure.
    - g. Network failure
    - h. Controller failure.
    - i. Instrument failure.
    - j. Control damper and valve actuator failure.
  4. Complete bibliography of documentation and media to be delivered to Owner.
  5. Description of testing plans and procedures.
  6. Description of Owner training.
- F. Delegated-Design Submittal: For DDC system products and installation indicated as being delegated.
1. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.

## 1.5 INFORMATIONAL SUBMITTALS

### A. Coordination Drawings:

1. Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - a. Product installation location shown in relationship to room, duct, pipe and equipment.
  - b. Structural members to which products will be attached.
  - c. Wall-mounted instruments located in finished space showing relationship to light switches, fire-alarm devices and other installed devices.
  - d. Size and location of wall access panels for products installed behind walls and requiring access.

### B. Qualification Data:

1. Systems Provider Qualification Data:

- a. Resume of project manager assigned to Project.
    - b. Resumes of application engineering staff assigned to Project.
    - c. Resumes of installation and programming technicians assigned to Project.
    - d. Resumes of service technicians assigned to Project.
    - e. Brief description of past project including physical address, floor area, number of floors, building system cooling and heating capacity and building's primary function.
    - f. Description of past project DDC system, noting similarities to Project scope and complexity indicated.
    - g. Names of staff assigned to past project that will also be assigned to execute work of this Project.
    - h. Owner contact information for past project including name, phone number, and e-mail address.
    - i. Contractor contact information for past project including name, phone number, and e-mail address.
    - j. Architect and Engineer contact information for past project including name, phone number, and e-mail address.
  2. Manufacturer's qualification data.
  3. Testing agency's qualifications data.
  - C. Product Certificates:
    1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.
    2. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with LonWorks.
  - D. Product Test Reports: For each product that requires testing to be performed by manufacturer.
  - E. Source quality-control reports.
  - F. Field quality-control reports.
  - G. Sample Warranty: For manufacturer's warranty.
- 1.6 CLOSEOUT SUBMITTALS
- A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.
    1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
      - a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
      - b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
      - c. As-built versions of submittal Product Data.



- d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
- e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
- f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
- g. Engineering, installation, and maintenance manuals that explain how to:
  - 1) Design and install new points, panels, and other hardware.
  - 2) Perform preventive maintenance and calibration.
  - 3) Debug hardware problems.
  - 4) Repair or replace hardware.
- h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
- i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
- j. List of recommended spare parts with part numbers and suppliers.
- k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
- l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
- m. Licenses, guarantees, and warranty documents.
- n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
- o. Owner training materials.

## 1.7 QUALITY ASSURANCE

- A. The Control System Contractor shall be qualified to work on Honeywell branded Tridium products (HON WEBS contractor) and have a full service DDC office. The office shall be staffed with applications engineers, software engineers and field technicians. This office shall maintain parts inventory and shall have all testing and diagnostic equipment necessary to support this work, as well as staff trained in the use of this equipment.
- B. Single Source Responsibility of Supplier: The Control System Contractor shall be responsible for the complete installation and proper operation of the control system. The Control System Contractor shall exclusively be in the regular and customary business of design, installation and service of computerized building management systems similar in size and complexity to the system specified. The Control System Contractor shall be the manufacturer of the primary DDC system components or shall have been the authorized representative for the primary DDC components manufacturer for at least 5 years. All control panels shall be assembled by the Control System Contractor in a UL-Certified 508A panel shop.
- C. Equipment and Materials: Equipment and materials shall be cataloged products of manufacturers regularly engaged in the production and installation of HVAC control systems.

Products shall be manufacturer's latest standard design and have been tested and proven in actual use.

D. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 DELIVERY, STORAGE AND HANDLING

- A. Maintain integrity of shipping cartons for each piece of equipment and control device through shipping, storage and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

1.9 JOB CONDITIONS

- A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to insure that the Work will be carried out in an orderly fashion. It shall be this Contractor's responsibility to check the Contract Documents for possible conflicts between his Work and that of other crafts in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers and structural and architectural features.

1.10 SEQUENCING

- A. Ensure that products of this section are supplied to affected trades in time to prevent interruption of construction progress.

1.11 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.
1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
  2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
    - a. Install updates only after receiving Owner's written authorization.
  3. Warranty service shall occur during normal business hours and commence within 8 hours of Owner's warranty service request.
  4. Warranty Period: Two year(s) from date of Substantial Completion.

## PART 2 - PRODUCTS

## 2.1 DDC SYSTEM MANUFACTURERS

- A. Acceptable Manufacturer: Honeywell Building Control Systems, which is located at: 1985 Douglas Dr. N.; Minneapolis, MN 55422; Toll Free Tel: 888-793-8193; Email: request info (buildingcontrols@honeywell.com). Provide Spyder controllers. <http://buildingcontrols.honeywell.com/>
- B. Provide BACnet Honeywell Tridium N4 hardware and software. VMI's existing front end server is running "WEBs-N4 Workbench" Version 4.4.73.24.
- C. Substitutions: Not permitted.

## 2.2 GENERAL

- A. The Building Management System (BAS) shall be comprised of a network of interoperable, stand-alone digital controllers, a network area controller, graphics and programming and other control devices for a complete system as specified herein.
- B. The installed system shall provide secure password access to all features, functions and data contained in the overall BAS.

## 2.3 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURE

- A. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system utilizing Open protocols in one open, interoperable system.
- B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. Physical connection of any BACnet control equipment, such as chillers, shall be via Ethernet or IP.
- C. All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.
- D. The supplied system shall incorporate the ability to access all data using HTML5 enabled browsers without requiring proprietary operator interface and configuration programs or browser plug-ins. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on the Operating System Server located in the Facilities Office on the LAN. Systems requiring proprietary database and user interface programs shall not be acceptable.
- E. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a "flat" single tiered architecture shall not be acceptable.
  - 1. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
  - 2. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

## 2.4 BAS SERVER HARDWARE

- A. Central Server. VMI currently has a virtual server for the post BAS located in Nichols Engineering Hall Network Hardware/Server Room 314. The new and existing BAS systems shall utilize the existing virtual server.

## 2.5 SYSTEM NETWORK CONTROLLER (SNC)

- A. These controllers are designed to manage communications between the programmable equipment controllers (PEC), application specific controllers (ASC) and advanced unitary controllers (AUC) which are connected to its communications trunks, manage communications between itself and other system network controllers (SNC) and with any operator workstations (OWS) that are part of the BAS, and perform control and operating strategies for the system based on information from any controller connected to the BAS.
- B. The controllers shall be fully programmable to meet the unique requirements of the facility it shall control.
- C. The controllers shall be capable of peer-to-peer communications with other SNC's and with any OWS connected to the BAS, whether the OWS is directly connected, connected via cellular modem or connected via the Internet.
- D. The communication protocols utilized for peer-to-peer communications between SNC's will be Niagara 4 Fox, BACnet TCP/IP and SNMP. Use of a proprietary communication protocol for peer-to-peer communications between SNC's is not allowed.
- E. The SNC shall employ a device count capacity license model that supports expansion capabilities.
- F. The SNC shall be enabled to support and shall be licensed with the following Open protocol drivers (client and server) by default:
  - 1. BACnet
  - 2. Lon
  - 3. MODBUS
  - 4. SNMP
  - 5. KNX
- G. The SNC shall be capable of executing application control programs to provide:
  - 1. Calendar functions.
  - 2. Scheduling.
  - 3. Trending.
  - 4. Alarm monitoring and routing.
  - 5. Time synchronization.
  - 6. Integration of LonWorks, BACnet, and MODBUS controller data.
  - 7. Network management functions for all SNC, PEC and ASC based devices.
- H. The SNC shall provide the following hardware features as a minimum:
  - 1. Two 10/100 Mbps Ethernet ports.
  - 2. Two Isolated RS-485 ports with biasing switches.
  - 3. 1 GB RAM
  - 4. 4 GB Flash Total Storage / 2 GB User Storage

5. Wi-Fi (Client or WAP)
  6. USB Flash Drive
  7. High Speed Field Bus Expansion
  8. -20-60 degrees C Ambient Operating Temperature
  9. Integrated 24 VAC/DC Global Power Supply
  10. MicroSD Memory Card Employing Encrypted Safe Boot Technology
- I. The SNC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 16 simultaneous users.
- J. The SNC shall provide alarm recognition, storage, routing, management and analysis to supplement distributed capabilities of equipment or application specific controllers.
- K. The SNC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via cellular modem, or wide-area network.
1. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but not limited to:
    - a. Alarm.
    - b. Return to normal.
    - c. To default.
  2. Alarms shall be annunciated in any of the following manners as defined by the user:
    - a. Screen message text.
    - b. Email of complete alarm message to multiple recipients.
    - c. Pagers via paging services that initiate a page on receipt of email message.
    - d. Graphics with flashing alarm object(s).
  3. The following shall be recorded by the SNC for each alarm (at a minimum):
    - a. Time and date.
    - b. Equipment (air handler #, access way, etc.).
    - c. Acknowledge time, date, and user who issued acknowledgement.
- L. Programming software and all controller "Setup Wizards" shall be embedded into the SNC.
- M. The SNC shall support the following security functions.
1. Module code signing to verify the author of programming tool and confirm that the code has not been altered or corrupted.
  2. Role-Based Access Control (RBAC) for managing user roles and permissions.
  3. Require users to use strong credentials.
  4. Data in Motion and Sensitive Data at Rest be encrypted.
  5. LDAP and Kerberos integration of access management.
- N. The SNC shall support the following data modeling structures to utilize Search; Hierarchy; Template; and Permission functionality:
1. Metadata: Descriptive tags to define the structure of properties.
  2. Tagging: Process to apply metadata to components

### 3. Tag Dictionary

- O. The SNC shall employ template functionality. Templates are a containerized set of configured data tags, graphics, histories, alarms... that are set to be deployed as a unit based upon manufacturer's controller and relationships. All lower level communicating controllers (PEC, AUC, AVAV, VFD.) shall have an associated template file for reuse on future project additions.
- P. The SNC shall be provided with a 5 Year Software Maintenance license. Labor to implement not included.

## 2.6 PROGRAMMABLE EQUIPMENT CONTROLLER (PEC)

- A. HVAC control shall be accomplished using LonMark or BACnet based devices where the application has a LonMark profile or BTL Listed PICS defined. Where LonMark devices are not available for a particular application, devices based on LonWorks shall be acceptable. For each LonWorks device that does not have LonMark certification, the device supplier shall provide an XIF file for the device. The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara 4 Framework, that allow standard and customizable control solutions required in executing the "Sequence of Operation".
- B. All PECs shall be application programmable and shall at all times maintain their certification. All control sequences within or programmed into the PEC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained.
- C. The PEC shall provide LED indication of communication and controller performance to the technician, without cover removal.
- D. The PEC shall not require any external configuration tool or programming tool. All configuration and programming tasks shall be accomplished and accessible from within the Niagara 4 environment.
- E. The following integral and remote Inputs/Outputs shall be supported per each PEC:
  - 1. Eight integral dry contact digital inputs.
  - 2. Any two digital inputs may be configured as pulse counters with a maximum pulse read rate of 15 Hz.
  - 3. Eight integral analog inputs (configurable as 0-10V, 0-10,000 ohm or, 20K NTC).
  - 4. Six integral 4-20 ma analog outputs.
  - 5. Eight integral 24 Vac Triac digital outputs, configurable as maintained or floating motor control outputs.
  - 6. One integral 20 Vdc, 65-mA power supply for auxiliary devices.
  - 7. If a 20 Vdc 65-mA power supply terminal is not integral to the PEC, provide at each PEC a separate, fully isolated, enclosed, current limited and regulated UL listed auxiliary power supply for power to auxiliary devices.
- F. Each PEC shall have expansion ability to support additional I/O requirements through the use of remote input/output modules.
- G. PEC Controllers shall support at minimum the following control techniques:

8. General-purpose control loops that can incorporate Demand Limit Control strategies, Set point reset, adaptive intelligent recovery, and time of day bypass.
9. General-purpose, non-linear control loops.
10. Start/stop Loops.
11. If/Then/Else logic loops.
12. Math Function loops (MIN, MAX, AVG, SUM, SUB, SQRT, MUL, DIV, ENTHALPY).

## 2.7 ADVANCED UNITARY CONTROLLER (AUC)

- A. The advanced unitary controller (AUC) platform shall be designed specifically to control HVAC - ventilation, filtration, heating, cooling, humidification, and distribution. Equipment includes: constant volume air handlers, VAV air handlers, packaged RTU, heat pumps, unit vents, fan coils, natural convection units and radiant panels. The control shall use LonMark or BACnet based devices where the application has a LonMark profile or BTL Listed PICS defined. Where LonMark devices are not available for a particular application, devices based on LonWorks shall be acceptable. For each LonWorks device that does not have LonMark certification, the device supplier shall provide an XIF file for the device. The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara 4 Framework, that allow standard and customizable control solutions required in executing the "Sequence of Operation".
- B. Minimum Requirements:
1. The controller shall be fully programmable with full functionality on any Niagara 4 brand platform.
    - a. Support downloads to the controller from any brand of Niagara 4 platform.
    - b. Support uploads from the controller to any brand of Niagara 4 platform.
    - c. Support simulation/debug mode of the controller.
    - d. Maintain native GUI.
    - e. Native function-block programming software and all controller "Setup Wizards" shall be embedded within the Niagara 4 environment.
  2. The controller shall be capable of either integrating with other devices or stand-alone operation.
  3. The controller shall have two microprocessors. The Host processor contains on-chip FLASH program memory, FLASH information memory, and RAM to run the main HVAC application. The second processor for network communications. Controller memory minimum requirements include:
    - a. FLASH Memory Capacity: 60 Kilobytes with 8 Kilobytes for application program.
    - b. FLASH Memory settings retained for ten years.
    - c. RAM: 2 Kilobytes.
  4. The controller shall have an internal time clock with the ability to automatically revert from a master time clock on failure.

- a. Operating Range: 24 hour, 365 day, multi-year calendar including day of week and configuration for automatic day-light savings time adjustment to occur on configured start and stop dates.
  - b. Accuracy:  $\pm$ 1 minute per month at 77 degrees F.
  - c. Power Failure Backup: 24 hours at 32 degrees to 122 degrees F.
5. The controller shall have Significant Event Notification, Periodic Update capability, and Failure Detect when network inputs fail to be detected within their configurable time frame.
6. The controller shall have an internal DC power supply to power external sensors.
  - a. Power Output: 20 VDC  $\pm$ 10% at 75 mA.
7. The controller shall have a visual indication (LED) of the status of the device:
  - a. Controller operating normally.
  - b. Controller in process of download.
  - c. Controller in manual mode under control of software tool.
  - d. Controller lost its configuration.
  - e. No power to controller, low voltage, or controller damage.
  - f. Processor and/or controller are not operating.
8. The minimum controller Environmental ratings.
  - a. Operating Temperature Ambient Rating: -40 degrees to 150 degrees F.
  - b. Storage Temperature Ambient Rating: -40 degrees to 150 degrees F.
  - c. Relative Humidity: 5% to 95% non-condensing.
9. The controller shall have the additional approval requirements, listings, and approvals:
  - a. UL/cUL (E87741) listed under UL916 (Standard for Open Energy Management Equipment) with plenum rating.
  - b. CSA (LR95329-3) Listed.
  - c. Meets FCC Part 15, Subpart B, Class B (radiated emissions) requirements.
  - d. Meets Canadian standard C108.8 (radiated emissions).
  - e. Conforms requirements European Consortium standard EN 61000-6-1; 2001 (EU Immunity).
  - f. Conforms requirements European Consortium standard EN 61000-6-3; 2001 (EU Emission).
10. The controller housing shall be UL plenum rated mounting to either a panel or DIN rail (standard EN50022; 7.5mm x 35mm).
11. The controller shall have a mix of digital inputs (DI), digital Triac outputs (DO), analog outputs (AO), and universal inputs (UI).
  - a. Analog outputs (AO) shall be capable of being configured as digital outputs (DO).
  - b. Input and Output wiring terminal strips shall be removable from the controller without disconnecting wiring.
  - c. Input and Output wiring terminals shall be designated with color coded labels.



- d. Universal inputs shall be capable of being configured as binary inputs, resistive inputs, voltage inputs (0-10 VDC), or current inputs (4-20 mA).
- 12. The controller shall provide "continuous" automated loop tuning with an Adaptive Integral Algorithm Control Loop.
- 13. The controller platform shall have standard HVAC application programs that are modifiable to support both the traditional and specialized "sequence of operations" as outlined in Section 4.
  - a. Discharge air control and low limit.
  - b. Pressure-dependent dual duct without flow mixing.
  - c. Variable air volume with return flow tracking.
  - d. Economizer with differential enthalpy.
  - e. Minimum airflow coordinated with CO2.
  - f. Unit ventilator cycle (1, 2, 3) 2-pipe.
  - g. Unit ventilator cycle (1, 2, 3) 2-pipe with face/bypass.
  - h. Unit ventilator cycle (1, 2, 3) 4-pipe.
  - i. Unit ventilator cycle (1, 2, 3) 4-pipe with EOC valve.

## 2.8 ADVANCED VARIABLE AIR VOLUME CONTROLLER (AVAV)

- A. The advanced VAV controller platform shall be designed specifically for room-level VAV control - pressure-independent air flow control, pressure dependent damper control, supply and exhaust pressurization/de-pressurization control; temperature, humidity, complex CO2, occupancy, and emergency control. Equipment includes: VAV terminal unit, VAV terminal unit with reheat, Series fan powered terminal unit, Parallel fan powered terminal unit, Supply and Exhaust air volume terminals and Constant volume dual-duct terminal unit. Control shall be accomplished using LonMark or BACnet based devices where the application has a LonMark profile or BTL Listed PICS defined. Where LonMark devices are not available for a particular application, devices based on LonWorks shall be acceptable. For each LonWorks device that does not have LonMark certification, the device supplier shall provide an XIF file for the device. The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara 4 Framework, that allow standard and customizable control solutions required in executing the "Sequence of Operation".
- B. Minimum Requirements:
  - 1. The controller shall be fully programmable with full functionality on any Niagara 4 brand platform.
    - a. Support downloads to the controller from any brand of Niagara 4 platform.
    - b. Support uploads from the controller to any brand of Niagara 4 platform.
    - c. Support simulation/debug mode of the controller.
    - d. Maintain native GUI.
    - e. Native function-block programming embedded software and all controller "Setup Wizards" shall be embedded within the Niagara 4 environment.
  - 2. The controller shall be capable of either integrating with other devices or stand-alone room-level control operation.

3. The controller shall have an internal velocity pressure sensor.
  - a. Sensor Type: Microbridge air flow sensor with dual integral restrictors.
  - b. Operating Range: 0 to 1.5 inch H<sub>2</sub>O.
  - c. Accuracy:  $\pm 2\%$  of full scale at 32 degrees to 122 degrees F; and  $\pm 1\%$  of full scale at null pressure.
4. The controller shall have two microprocessors. The Host processor contains on-chip FLASH program memory, FLASH information memory, and RAM to run the main HVAC application. The second processor for network communications.
  - a. FLASH Memory Capacity: 60 Kilobytes with 8 Kilobytes for application program.
  - b. FLASH Memory settings retained for ten years.
  - c. RAM: 2 Kilobytes.
5. The controller shall have an internal time clock with the ability to automatically revert from a master time clock on failure.
  - a. Operating Range: 24 hour, 365 day, multi-year calendar including day of week and configuration for automatic day-light savings time adjustment to occur on configured start and stop dates.
  - b. Accuracy:  $\pm 1$  minute per month at 77 degrees F.
  - c. Power Failure Backup: 24 hours at 32 degrees to 122 degrees F.
6. The controller shall have Significant Event Notification, Periodic Update capability and Failure Detect when network inputs fail to be detected within their configurable time frame.
7. The controller shall have an internal DC power supply to power external sensors.
  - a. Power Output: 20 VDC  $\pm 10\%$  at 75 mA.
8. The controller shall have a visual indication (LED) of the status of the device:
  - a. Controller operating normally.
  - b. Controller in process of download.
  - c. Controller in manual mode under control of software tool.
  - d. Controller lost its configuration.
  - e. No power to controller, low voltage, or controller damage.
  - f. Processor and/or controller are not operating.
9. The minimum controller Environmental ratings:
  - a. Operating Temperature Ambient Rating: 32 degrees to 122 degrees F.
  - b. Storage Temperature Ambient Rating: 32 degrees to 122 degrees F.
  - c. Relative Humidity: 5% to 95% non-condensing.
10. The controller shall have the additional approval requirements, listings, and approvals:
  - a. UL/cUL (E87741) listed under UL916 (Standard for Open Energy Management Equipment) with plenum rating.

- b. CSA (LR95329-3) Listed.
  - c. Meets FCC Part 15, Subpart B, Class B (radiated emissions) requirements.
  - d. Meets Canadian standard C108.8 (radiated emissions).
  - e. Conforms requirements European Consortium standard EN 61000-6-1; 2001 (EU Immunity).
  - f. Conforms requirements European Consortium standard EN 61000-6-3; 2001 (EU Emission).
11. The controller housing shall be UL plenum rated mounting to either a panel or DIN rail (standard EN50022; 7.5mm x 35mm).
12. The controller shall provide an integrated actuator option.
- a. Actuator type: Series Floating.
  - b. Rotation stroke: 95 degrees &plusmn;3 degrees for CW or CCW opening dampers.
  - c. Torque rating: 44 lb-inch.
  - d. Run time for 90 degrees rotation: 90 seconds at 60 Hz.
13. The controller shall have digital inputs (DI), digital Triac outputs (DO), three analog outputs (AO), and universal inputs (UI).
- a. Analog outputs (AO) shall be capable of being configured as digital outputs (DO).
  - b. Input and Output wiring terminal strips shall be removable from the controller without disconnecting wiring.
  - c. Input and Output wiring terminals shall be designated with color coded labels.
14. The controller shall provide "continuous" automated loop tuning with an Adaptive Integral Algorithm Control Loop.
15. The controller shall have a loop execution response time of 1 second.
16. The controller platform shall have standard HVAC application programs that are modifiable to support both the traditional and specialized "sequence of operations" as outlined in Section 4.
- a. VAV terminal unit.
  - b. VAV terminal unit fan speed control.
  - c. Series fan.
  - d. Parallel fan.
  - e. Regulated air volume (room pressurization/de-pressurization).
  - f. CV dual-duct.
  - g. Room CO2 control.
  - h. Room Humidity.
  - i. TOD occupancy sensor stand-by set points.

## 2.9 WALL MODULES

- A. Wall Mount Room Temperature Sensors Non-Common Spaces: 2-wire, non-polarity sensitive, Sylk communicating wall module which communicates with all Spyder programmable controllers and ComfortPoint open controllers that are enabled with Sylk.

Wall modules shall include display, setpoint adjustment and override. Additional options shall include fan speed control, built-in humidity and built-in CO2. Room Temperature Sensors shall be 20,000-ohm thermistor type with a temperature range of 32 to 125 degrees F. The sensor shall be complete with a decorative cover and suitable for mounting over a standard electrical utility box. CO2 measurement shall require no calibration for the life of the sensor. Honeywell TR42.

1. Accuracy:
  - a. Temperature: plus or minus 0.36 deg F at 77 deg F.
  - b. Humidity: plus or minus 3 percent at 20-80 percent relative humidity.
  - c. CO2: plus or minus 30 ppm plus 3 percent of measured value.

- B. Wall Mount Room Temperature Sensors Common Spaces: 2-wire, non-polarity sensitive, wall module which communicate with all Spyder programmable controllers Wall modules shall have blank cover plate. Additional options shall include built-in humidity sensor. Room Temperature Sensors shall be 20,000-ohm thermistor type with a temperature range of 45 to 99 degrees F. The sensor shall be complete with a decorative cover and suitable for mounting over a standard electrical utility box. Honeywell TR21.

1. Accuracy:
  - a. Temperature: plus or minus 0.36 deg F at 77 deg F.
  - b. Humidity: plus or minus 5 percent at 20-80 percent relative humidity.

## 2.10 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional to design DDC system to satisfy requirements indicated.

1. System Performance Objectives:
  - a. DDC system shall manage HVAC systems.
  - b. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
  - c. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
  - d. DDC system shall operate while unattended by an operator and through operator interaction.
  - e. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.

- B. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

- C. Environmental Conditions for Controllers, Gateways and Routers:

1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.
  - a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance.
2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
  - a. Outdoors, Protected: Type 12.
  - b. Outdoors, Unprotected: Type 4X.
  - c. Indoors, Heated with Filtered Ventilation: Type 2.
  - d. Indoors, Heated with Non-Filtered Ventilation: Type 12.
  - e. Indoors, Heated and Air Conditioned: Type 1.
  - f. Mechanical Equipment Rooms:
    - 1) Chiller and Boiler Rooms: Type 12.
    - 2) Air-Moving Equipment Rooms: Type 2.

D. Environmental Conditions for Instruments:

1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
  - a. If instruments alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance.
2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments and actuators not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
  - a. Outdoors, Protected: Type 12.
  - b. Outdoors, Unprotected: Type 4X.
  - c. Indoors, Heated with Filtered Ventilation: Type 2.
  - d. Indoors, Heated with Non-Filtered Ventilation: Type 12.
  - e. Indoors, Heated and Air-conditioned: Type 1.
  - f. Mechanical Equipment Rooms:
    - 1) Chiller and Boiler Rooms: Type 12.
    - 2) Air-Moving Equipment Rooms: Type 12.

E. Electric Power Quality:

1. Power-Line Surges:

- a. Protect DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.
  - b. Do not use fuses for surge protection.
  - c. Test protection in the normal mode and in the common mode, using the following two waveforms:
    - 1) 10-by-1000-mic.sec. waveform with a peak voltage of 1500 V and a peak current of 60 A.
    - 2) 8-by-20-mic.sec. waveform with a peak voltage of 1000 V and a peak current of 500 A.
2. Power Conditioning:
- a. Protect DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner shall be as follows:
    - 1) At 85 percent load, output voltage shall not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
    - 2) During load changes from zero to full load, output voltage shall not deviate by more than plus or minus 3 percent of nominal.
    - 3) Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.
    - 4) Total harmonic distortion shall not exceed 3-1/2 percent at full load.
3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.

F. Backup Power Source:

1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

G. Continuity of Operation after Electric Power Interruption:

1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

## 2.11 SYSTEM ARCHITECTURE

- A. System architecture shall consist of no more than two levels of LANs.
- B. DDC system shall consist of dedicated LANs that are not shared with other building systems and tenant data and communication networks.

- C. System architecture shall perform modifications without having to remove and replace existing network equipment.
- D. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.
- E. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its' own control, alarm management and historical data collection.
- F. Special Network Architecture Requirements:
  - 1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to controller that is controlling air-handling system air-handling unit(s). Basically, create a DDC system LAN that aligns with air-handling system being controlled.

## 2.12 DDC SYSTEM OPERATOR INTERFACES

- A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:
  - 1. Desktop and portable workstation with hardwired connection through LAN port.
  - 2. Portable operator terminal with hardwired connection through LAN port.
  - 3. Portable operator workstation with wireless connection through LAN router.
  - 4. Mobile device and application with secured wireless connection through LAN router or cellular data service.
  - 5. Remote connection through web access.
- B. Access to system, regardless of operator means used, shall be transparent to operator.
- C. Network Ports: For hardwired connection of desktop or portable workstation. Network port shall be easily accessible, properly protected, clearly labeled.
- D. Critical Alarm Reporting:
  - 1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
  - 2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
  - 3. DDC system shall notify recipients by any or all means, including e-mail, text message and prerecorded phone message to mobile and landline phone numbers.
- E. Simultaneous Operator Use: Capable of accommodating up to 10 simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

## 2.13 NETWORKS

- A. Acceptable networks for connecting workstations, mobile devices, and network controllers include the following:
  - 1. ATA 878.1, ARCNET.
  - 2. CEA-709.1-C.
  - 3. IP.
  - 4. IEEE 8802-3, Ethernet.
- B. Acceptable networks for connecting programmable application controllers include the following:
  - 1. ATA 878.1, ARCNET.
  - 2. CEA-709.1-C.
  - 3. IP.
  - 4. IEEE 8802-3, Ethernet.
- C. Acceptable networks for connecting application-specific controllers include the following:
  - 1. ATA 878.1, ARCNET.
  - 2. CEA-709.1-C.
  - 3. EIA-485A.
  - 4. IP.
  - 5. IEEE 8802-3, Ethernet.

## 2.14 NETWORK COMMUNICATION PROTOCOL

- A. Network communication protocol(s) used throughout entire DDC system shall be open to Owner and available to other companies for use in making future modifications to DDC system.
- B. ASHRAE 135 Protocol:
  - 1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
  - 2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
  - 3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
  - 4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

## 2.15 DESKTOP WORKSTATIONS

- A. Description: A tower or all-in-one computer designed for normal use at a single, semi-permanent location will be furnished by VMI.



## 2.16 BAS SERVER AND WEB BROWSER GUI - SYSTEM OVERVIEW

- A. The BAS Contractor shall upgrade the existing Honeywell Tridium “WEBs-N4 Workbench” version 4.4.73.24 to accommodate the new Buildings on the existing server. Provide system software based on server/thin-client architecture, designed around the open standards of web technology. The BAS server shall communicate using Ethernet and TCP. Server shall be accessed using a web browser over Owner intranet and remotely over the Internet.
- B. The intent of the thin-client architecture is to provide the operator(s) complete access to the BAS system via a web browser. The thin-client web browser Graphical User Interface (GUI) shall be browser and operating system agnostic, meaning it will support HTML5 enabled browsers without requiring proprietary operator interface and configuration programs or browser plug-ins. Microsoft, Firefox, and Chrome browsers (current released versions), and Windows as well as non-Windows operating systems.
- C. The BAS server software shall support at least the following server platforms (Windows 7, 8.1, Server 12). The BAS server software shall be developed and tested by the manufacturer of the system stand-alone controllers and network controllers/routers.
- D. The web browser GUI shall provide a completely interactive user interface and shall provide a HTML5 experience that supports the following features as a minimum:
  - 1. Trending.
  - 2. Scheduling.
  - 3. Electrical demand limiting.
  - 4. Duty Cycling.
  - 5. Downloading Memory to field devices.
  - 6. Real time 'live' Graphic Programs.
  - 7. Tree Navigation.
  - 8. Parameter change of properties.
  - 9. Set point adjustments.
  - 10. Alarm / event information.
  - 11. Configuration of operators.
  - 12. Execution of global commands.
  - 13. Add, delete, and modify graphics and displayed data.
- E. Software Components: All software shall be the most current version. All software components of the BAS system software shall be provided and installed as part of this project. BAS software components shall include:
  - 1. Server Software, Database and Web Browser Graphical User Interface.
  - 2. 5 Year Software Maintenance license. Labor to implement not included.
  - 3. Embedded System Configuration Utilities for future modifications to the system and controllers.
  - 4. Embedded Graphical Programming Tools.
  - 5. Embedded Direct Digital Control software.
  - 6. Embedded Application Software.
- F. BAS Server Database: The BAS server software shall utilize a Java Database Connectivity (JDBC) compatible database such as: MS SQL 8.0, Oracle 8i or IBM DB2. BAS systems written to Non -Standard and/or Proprietary databases are NOT acceptable.

- G. Thin Client - Web Browser Based: The GUI shall be thin client or browser based and shall meet the following criteria:
1. Web Browser's for PC's: Only the current released browser (Explorer/Firefox/Chrome) will be required as the GUI and a valid connection to the server network. No installation of any custom software shall be required on the operator's GUI workstation/client. Connection shall be over VMI's existing intranet.
  2. Secure Socket Layers: Communication between the Web Browser GUI and BAS server shall offer encryption using 128-bit encryption technology within Secure Socket Layers (SSL). Communication protocol shall be Hyper-Text Transfer Protocol (HTTP).

## 2.17 WEB BROWSER GRAPHICAL USER INTERFACE

- A. Web Browser Navigation: The Thin Client web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to "feel" like a single application, and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser to accomplish requirements of this specification. The Web Browser GUI shall (as a minimum) provide for navigation, and for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic set point controls, configuration menus for operator access, reports and reporting actions for events.
- B. Login: On launching the web browser and selecting the appropriate domain name or IP address, the operator shall be presented with a login page that will require a login name and strong password. Navigation in the system shall be dependent on the operator's role-based application control privileges.
- C. Navigation: Navigation through the GUI shall be accomplished by clicking on the appropriate level of a navigation tree (consisting of an expandable and collapsible tree control like Microsoft's Explorer program) and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane shall be displayed simultaneously, enabling the operator to select a specific system or equipment and view the corresponding graphic. The navigation tree shall as a minimum provide the following views: Geographic, Network, Groups and Configuration.
1. Geographic View shall display a logical geographic hierarchy of the system including: cities, sites, buildings, building systems, floors, equipment and objects.
  2. Groups View shall display Scheduled Groups and custom reports.
  3. Configuration View shall display all the configuration categories (Operators, Schedule, Event, Reporting and Roles).
- D. Action Pane: The Action Pane shall provide several functional views for each subsystem specified. A functional view shall be accessed by clicking on the corresponding button:
1. Graphics: Using graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floor-plans, equipment drawings, active graphic set point controls, web content and other valid HTML elements. The data on each graphic page shall automatically refresh.
  2. Dashboards: User customizable data using drag and drop HTML5 elements. Shall include Web Charts, Gauges, and other custom developed widgets for web browser. User shall have ability to save custom dashboards.

3. Search: User shall have multiple options for searching data based upon Tags. Associated equipment, real time data, Properties, and Trends shall be available in result.
  4. Properties: Shall include graphic controls and text for the following: Locking or overriding objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the operator to depress an 'accept/cancel' button.
  5. Schedules: Shall be used to create, modify/edit and view schedules based on the systems hierarchy (using the navigation tree).
  6. Alarms: Shall be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.
  7. Charting: Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling. User shall have ability to create HTML charts through web browser without utilizing chart builder. User shall be able to drag and drop single or multiple data points, including schedules, and apply status colors for analysis.
  8. Logic - Live Graphic Programs: Shall be used to display 'live' graphic programs of the control algorithm, (micro block programming) for the mechanical/electrical system selected in the navigation tree.
  9. Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.
- E. Color Graphics: The Web Browser GUI shall make extensive use of color in the graphic pane to communicate information related to set points and comfort. Animated. gifs or .jpg, vector scalable, active set point graphic controls shall be used to enhance usability. Graphics tools used to create Web Browser graphics shall be non-proprietary and conform to the following basic criteria:
1. Display Size: The GUI workstation software shall graphically display in a minimum of 1024 by 768 pixels 24 bit True Color.
  2. General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.
  3. Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, as selected by Owner. Provide a visual display of temperature relative to their respective set points. The colors shall be updated dynamically as a zone's actual comfort condition changes.
  4. Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability.
  5. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:
    - a. Each piece of equipment monitored or controlled including each terminal unit.
    - b. Each building.
    - c. Each floor and zone controlled.
- F. Hierarchical Schedules: Utilizing the Navigation Tree displayed in the web browser GUI, an operator (with proper access credentials) shall be able to define a Normal, Holiday or Override schedule for an individual piece of equipment or room, or choose to apply a hierarchical schedule to the entire system, site or floor area. For example, Independence Day 'Holiday' for

every level in the system would be created by clicking at the top of the geographic hierarchy defined in the Navigation Tree. No further operator intervention would be required and every control module in the system would be automatically downloaded with the 'Independence Day' Holiday. All schedules that affect the system/area/equipment highlighted in the Navigation Tree shall be shown in a summary schedule table and graph.

1. Schedules: Schedules shall comply with the LonWorks and BACnet standards, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:
    - a. Types of schedule shall be Normal, Holiday or Override.
    - b. A specific date.
    - c. A range of dates.
    - d. Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any).
    - e. Wildcard (example, allow combinations like second Tuesday of every month).
  2. Schedule Categories: The system shall allow operators to define and edit scheduling categories (different types of "things" to be scheduled; for example, lighting, HVAC occupancy, etc.). The categories shall include: name, description, icon (to display in the hierarchy tree when icon option is selected) and type of value to be scheduled.
  3. Schedule Groups: In addition to hierarchical scheduling, operators shall be able to define functional Schedule Groups, comprised of an arbitrary group of areas/rooms/equipment scattered throughout the facility and site. For example, the operator shall be able to define an 'individual tenant' group - who may occupy different areas within a building or buildings. Schedules applied to the 'tenant group' shall automatically be downloaded to control modules affecting spaces occupied by the 'tenant group'.
  4. Intelligent Scheduling: The control system shall be intelligent enough to automatically turn on any supporting equipment needed to control the environment in an occupied space. If the operator schedules an individual room in a VAV system for occupancy, for example, the control logic shall automatically turn on the VAV air handling unit, chiller, boiler and/or any other equipment required to maintain the specified comfort and environmental conditions within the room.
  5. Partial Day Exceptions: Schedule events shall be able to accommodate a time range specified by the operator (ex: board meeting from 6 pm to 9 pm overrides Normal schedule for conference room).
  6. Schedule Summary Graph: The schedule summary graph shall clearly show Normal versus Holiday versus Override Schedules and the net operating schedule that results from all contributing schedules. Note: In case of priority conflict between schedules at the different geographic hierarchy, the schedule for the more detailed geographic level shall apply.
- G. Alarms: Alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by selecting an 'Alarms' view. Alarms, and reporting actions shall have the following capabilities:
1. Alarms View: Each Alarm shall display an Alarms Category (using a different icon for each alarm category), date/time of occurrence, current status, alarm report and a bold URL link to the associated graphic for the selected system, area or equipment. The URL link shall indicate the system location, address and other pertinent information. An

- operator shall easily be able to sort events, edit event templates and categories, acknowledge or force a return to normal in the Events View as specified in this section.
2. Alarm Categories: The operator shall be able to create, edit or delete alarm categories such as HVAC, Maintenance, Fire, or Generator. An icon shall be associated with each alarm category, enabling the operator to easily sort through multiple events displayed.
  3. Alarm Templates: Alarm template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity of alarm, acknowledgement requirements, and high/low limit and out of range information.
  4. Alarm Areas: Alarm Areas enable an operator to assign specific Alarm Categories to specific Alarm Reporting Actions. For example, it shall be possible for an operator to assign all HVAC Maintenance Alarm on the 1st floor of a building to email the technician responsible for maintenance. The Navigation Tree shall be used to setup Alarm Areas in the Graphic Pane.
  5. Alarm Time/Date Stamp: All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.
  6. Alarm Configuration: Operators shall be able to define the type of Alarm generated per object. A 'network' view of the Navigation Tree shall expose all objects and their respective Alarm Configuration. Configuration shall include assignment of Alarm, type of Acknowledgement and notification for return to normal or fault status.
  7. Alarm Summary Counter: The view of Alarm in the Graphic Pane shall provide a numeric counter, indicating how many Alarms are active (in alarm), require acknowledgement and total number of Alarms in the BAS Server database.
  8. Alarm Auto-Deletion: Alarms that are acknowledged and closed shall be auto-deleted from the database and archived to a text file after an operator defined period.
  9. Alarm Reporting Actions: Alarm Reporting Actions specified shall be automatically launched (under certain conditions) after an Alarm is received by the BAS server software. Operators shall be able to easily define these Reporting Actions using the Navigation Tree and Graphic Pane through the web browser GUI. Reporting Actions shall be as follows:
    - a. Print: Alarm information shall be printed to the BAS server's PC or a networked printer.
    - b. Email: Email shall be sent via any POP3-compatible e-mail server (most Internet Service Providers use POP3). Email messages may be copied to several email accounts. Note: Email reporting action shall also be used to support alphanumeric paging services, where email servers support pagers.
    - c. File Write: The ASCII File write reporting action shall enable the operator to append operator defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the operator. The operator may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).
    - d. Write Property: The write property reporting action updates a property value in a hardware module.
    - e. SNMP: The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an alarm.
    - f. Run External Program: The Run External Program reporting action launches specified program in response to an event.

H. Trends: As system is engineered, all points shall be enabled to trend. Trends shall both be

displayed and user configurable through the Web Browser GUI. Trends shall comprise analog, digital or calculated points simultaneously. A trend log's properties shall be editable using the Navigation Tree and Graphic Pane.

1. Viewing Trends: The operator shall have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane. The system shall allow y- and x-axis maximum ranges to be specified and shall be able to simultaneously graphically display multiple trends per graph.
  2. Local Trends: Trend data shall be collected locally by Multi-Equipment/Single Equipment general-purpose controllers, and periodically uploaded to the BAS server if historical trending is enabled for the object. Trend data, including run time hours and start time date shall be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.
  3. Resolution. Sample intervals shall be as small as one second. Each trended point will have the ability to be trended at a different trend interval. When multiple points are selected for displays that have different trend intervals, the system will automatically scale the axis.
  4. Dynamic Update. Trends shall be able to dynamically update at operator-defined intervals.
  5. Zoom/Pan. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and 'pan through' historical data by simply scrolling the mouse.
  6. Numeric Value Display. It shall be possible to pick any sample on a trend and have the numerical value displayed.
  7. Copy/Paste. The operator shall have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard keystrokes (i.e. CTRL+C, CTRL+V).
- I. Security Access: Systems that are accessed from the web browser GUI to BAS server shall require a Login Name and Strong Password. Access to different areas of the BAS system shall be defined in terms of Role-Based Access Control privileges as specified:
1. Roles: Roles shall reflect the actual roles of different types of operators. Each role shall comprise a set of 'easily understood English language' privileges. Roles shall be defined in terms of View, Edit and Function Privileges.
    - a. View Privileges shall comprise: Navigation, Network, and Configuration Trees, Operators, Roles and Privileges, Alarm/Event Template and Reporting Action.
    - b. Edit Privileges shall comprise: Set point, Tuning and Logic, Manual Override, and Point Assignment Parameters.
    - c. Function Privileges shall comprise: Alarm/Event Acknowledgement, Control Module Memory Download, Upload, Schedules, Schedule Groups, Manual Commands, Print and Alarm/Event Maintenance.
  2. Geographic Assignment of Roles: Roles shall be geographically assigned using a similar expandable/collapsible navigation tree. For example, it shall be possible to assign two HVAC Technicians with similar competencies (and the same operator defined HVAC Role) to different areas of the system.

## 2.18 GRAPHICAL PROGRAMMING

- A. The system software shall include a Graphic Programming Language (GPL) for all DDC

control algorithms resident in all control modules. Any system that does not use a drag and drop method of graphical icon programming shall not be accepted. All systems shall use a GPL method used to create a sequence of operations by assembling graphic microblocks that represent each of the commands or functions necessary to complete a control sequence. Microblocks represent common logical control devices used in conventional control systems, such as relays, switches, high signal selectors etc., in addition to the more complex DDC and energy management strategies such as PID loops and optimum start. Each microblock shall be interactive and contain the programming necessary to execute the function of the device it represents.

- B. Graphic programming shall be performed while on screen and using a mouse; each microblock shall be selected from a microblock library and assembled with other microblocks necessary to complete the specified sequence. Microblocks are then interconnected on screen using graphic "wires," each forming a logical connection. Once assembled, each logical grouping of microblocks and their interconnecting wires then forms a graphic function block which may be used to control any piece of equipment with a similar point configuration and sequence of operation.
- C. Graphic Sequence: The clarity of the graphic sequence shall be such that the operator has the ability to verify that system programming meets the specifications, without having to learn or interpret a manufacturer's unique programming language. The graphic programming shall be self-documenting and provide the operator with an understandable and exact representation of each sequence of operation.
- D. GPL Capabilities: The following is a minimum definition of the capabilities of the Graphic Programming software:
  - 1. Function Block (FB): Shall be a collection of points, microblocks and wires which have been connected together for the specific purpose of controlling a piece of HVAC equipment or a single mechanical system.
  - 2. Logical I/O: Input/Output points shall interface with the control modules in order to read various signals and/or values or to transmit signal or values to controlled devices.
  - 3. Microblocks: Shall be software devices that are represented graphically and may be connected together to perform a specified sequence. A library of microblocks shall be submitted with the control contractors bid.
  - 4. Wires: Shall be Graphical elements used to form logical connections between microblocks and between logical I/O.
  - 5. Reference Labels: Labels shall be similar to wires in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection, i.e. two points labeled 'A' on a drawing are logically connected even though there is no wire between them.
  - 6. Parameter: A parameter shall be a value that may be tied to the input of a microblock.
  - 7. Properties: Dialog boxes shall appear after a microblock has been inserted which has editable parameters associated with it. Default parameter dialog boxes shall contain various editable and non-editable fields, and shall contain 'push buttons' for the purpose of selecting default parameter settings.
  - 8. Icon: An icon shall be graphic representation of a software program. Each graphic microblock has an icon associated with it that graphically describes its function.
  - 9. Menu-bar Icon: Shall be an icon that is displayed on the menu bar on the GPL screen, which represents its associated graphic microblock.
  - 10. Live Graphical Programs: The Graphic Programming software shall support a 'live' mode, where all input/output data, calculated data and set points shall be displayed in a 'live' real-time mode.

## 2.19 LONWORKS NETWORK MANAGEMENT

- A. Systems requiring the use of third-party LonWorks network management tools shall not be accepted.
- B. Network management shall include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.
- C. The Network configuration tool shall also provide diagnostics to identify devices on the network, to reset devices and to view health and status counters within devices.
- D. These tools shall provide the ability to "learn" an existing LonWorks network, regardless of what network management tool(s) were used to install the existing network, so that existing LonWorks devices and newly added devices are part of a single network management database.
- E. The network management database shall be resident in the Network Area Controller (NAC), ensuring that anyone with proper authorization has access to the network management database at all times. Systems employing network management databases that are not resident, at all times and within the control system shall not be accepted.

## 2.20 REPORTS

- A. Reports and Logs:
  - 1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
  - 2. Each report shall be definable as to data content, format, interval and date.
  - 3. Report data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on server for historical reporting.
  - 4. Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
  - 5. Reports and logs shall be stored on server hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
  - 6. Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.
- B. Standard Reports: Standard DDC system reports shall be provided and operator shall be able to customize reports later.
  - 1. All I/O: With current status and values.
  - 2. Alarm: All current alarms, except those in alarm lockout.
  - 3. Disabled I/O: All I/O points that are disabled.
  - 4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
  - 5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
  - 6. Logs:
    - a. Alarm history.
    - b. System messages.
    - c. System events.
    - d. Trends.



- C. Custom Reports: Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.
- D. HVAC Equipment Reports: Prepare Project-specific reports.
  - 1. Chiller Report: Daily report showing operating conditions of each chiller according to ASHRAE 147, including, but not limited to, the following:
    - a. Chilled-water entering temperature.
    - b. Chilled-water leaving temperature.
    - c. Chilled-water flow rate.
    - d. Chilled-water inlet and outlet pressures.
    - e. Evaporator refrigerant pressure and temperature.
    - f. Condenser refrigerant pressure and liquid temperature.
    - g. Condenser-water entering temperature.
    - h. Condenser-water leaving temperature.
    - i. Condenser-water flow rate.
    - j. Refrigerant levels.
    - k. Oil pressure and temperature.
    - l. Oil level.
    - m. Compressor refrigerant discharge temperature.
    - n. Compressor refrigerant suction temperature.
    - o. Addition of refrigerant.
    - p. Addition of oil.
    - q. Vibration levels or observation that vibration is not excessive.
    - r. Motor amperes per phase.
    - s. Motor volts per phase.
    - t. Refrigerant monitor level (PPM).
    - u. Purge exhaust time or discharge count.
    - v. Ambient temperature (dry bulb and wet bulb).
    - w. Date and time logged.
- E. HVAC System Efficiency Reports: Prepare Project-specific monthly HVAC system efficiency reports.
  - 1. Prepare report for each chilled-water system, indicating the following:
    - a. Time period being reported with beginning and end date, and time indicated.
    - b. Cooling energy supplied during time period.
    - c. Power energy consumed during time period by cooling equipment used to produce cooling energy supplied. List power consumed for each individual piece of equipment in system and summed total of all equipment in system.
    - d. Energy efficiency coefficient of performance determined by dividing power energy consumed into cooling energy supplied.
    - e. Energy efficiency determined by dividing cooling energy supplied into power energy consumed.
    - f. Units of measure used in report shall be consistent with units indicated for system.
  - 2. Prepare report for each hot-water system, indicating the following:

- a. Time period being reported with beginning and end date, and time indicated.
    - b. Cooling energy supplied during time period.
    - c. Energy efficiency determined by dividing heating energy supplied into fuel energy consumed.
    - d. Units of measure used in report shall be consistent with units indicated for system.
  3. Prepare report for each steam system, indicating the following:
    - a. Time period being reported with beginning and end date, and time indicated.
    - b. Cooling energy supplied during time period.
    - c. Fuel consumed during time period by boilers used to produce heating energy supplied. List fuel consumed for each individual piece of equipment in system and summed total of all equipment in system.
    - d. Energy efficiency determined by dividing heating energy supplied into fuel energy consumed.
    - e. Units of measure used in report shall be consistent with units indicated for system.
- F. Weather Reports:
1. Include monthly report showing the following:
    - a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
    - b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
    - c. Daily minimum, maximum, and average relative humidity.
  2. Include annual (12-month) report showing the following:
    - a. Monthly minimum, maximum, and average outdoor dry-bulb temperature.
    - b. Monthly minimum, maximum, and average outdoor wet-bulb temperature.
    - c. Monthly minimum, maximum, and average relative humidity.
- G. Standard Trends:
1. Trend all I/O point present values, set points, and other parameters indicated for trending.
  2. Trends shall be associated into groups, and a trend report shall be set up for each group.
  3. Trends shall be stored within DDC controller and uploaded to hard drives automatically on reaching 75 of DDC controller buffer limit, or by operator request, or by archiving time schedule.
  4. Preset trend intervals for each I/O point after review with Owner.
  5. Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.
  6. When drive storage memory is full, most recent data shall overwrite oldest data.
  7. Archived and real-time trend data shall be available for viewing numerically and graphically by operators.
- H. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.
1. Each trend shall include interval, start time, and stop time.
  2. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on server hard drives.

3. Data shall be retrievable for use in spreadsheets and standard database programs.

## 2.21 OFFICE APPLICATION SOFTWARE

- A. Include current version of office application software at time of Substantial Completion.
- B. Office application software package shall include multiple separate applications and use a common platform for all applications, similar to Microsoft's "Office Professional."
  1. Database.
  2. E-mail.
  3. Presentation.
  4. Publisher.
  5. Spreadsheet.
  6. Word processing.

## 2.22 ASHRAE 135 GATEWAYS

- A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, chillers, and variable-speed drives.
- B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Owner.
- C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.
- D. Gateway Minimum Requirements:
  1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
  2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.
  3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.
  4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs according to ASHRAE 135.
  5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
  6. Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

## 2.23 ASHRAE 135 PROTOCOL ANALYZER

- A. Analyzer and required cables and fittings for connection to ASHRAE 135 network.

B. Analyzer shall include the following minimum capabilities:

1. Capture and store to a file data traffic on all network levels.
2. Measure bandwidth usage.
3. Filtering options with ability to ignore select traffic.

## 2.24 CEA-709.1-C NETWORK HARDWARE

A. Routers:

1. Network routers, including routers configured as repeaters, shall comply with requirements of CEA-709.1-C and include connection between two or more CEA-709.3 TP/FT-10 channels or between two or more CEA-709.3 TP/FT-10 channels and a TP/XF-1250 channel.
2. IP Routers:
  - a. Perform layer three routing of CEA-709.1-C packets over an IP network according to CEA-852-B.
  - b. Include appropriate connection to the IP network and connections to CEA-709.3 TP/FT-10 or TP/XF-1250 network.
  - c. Support the Dynamic Host Configuration Protocol for IP configuration and use of an CEA-852-B Configuration Server (for CEA-852-B configuration), but shall not rely on these services for configuration.
  - d. Capable of manual configuration via a console RS-232 port.

B. Gateways:

1. Perform bidirectional protocol translation from one non-CEA-709.1-C protocol to CEA-709.1-C.
2. Incorporate a network connection to a TP/FT-10 network according to CEA-709.3 and a connection for a non-CEA-709.1-C network.

## 2.25 NETWORK CONTROLLERS

A. General Network Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
3. Controller shall have enough memory to support its operating system, database, and programming requirements.
4. Data shall be shared between networked controllers and other network devices.
5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Controllers that perform scheduling shall have a real-time clock.

7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
  8. Controllers shall be fully programmable.
- B. Communication:
1. Network controllers shall communicate with other devices on DDC network.
  2. Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.
- C. Operator Interface:
1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or mobile device.
- D. Serviceability:
1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
  2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
  3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

END OF SECTION 230923