

# Duke

**FACILITIES MANAGEMENT**  
**CAD STANDARDS GUIDELINE**

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### 1 Acronyms

Architect/Engineer/Contractor	AEC
American Institute of Architects	AIA
Building Information Modeling	BIM
Color-Dependent Plot Style Table File Extension	CTB
Computer-Aided Design	CAD
Critical Systems Building	CSB
Critical Systems Team	CST
Design Development	DD
Duke University	Duke
Duke Utility & Engineering Services	DUES
Drawing File Extension - AutoCAD® Native	DWG
Infor – Enterprise Asset Management	EAM
External Reference File	Xref
Facilities Management Department	FMD
Geographic Information Systems	GIS
Mechanical/Electrical/Plumbing/Fire Protection	MEPFP
United States National CAD Standard®	NCS
Schematic Design	SD
Variable Air Volume	VAV

## 2 Introduction

The Duke Facilities Management Department ([FMD](#)) is responsible for the management of over 6.8m GSF of buildings, utility infrastructure and grounds on campus. Among the many responsibilities within Duke FMD is the process of generating and maintaining accurate documentation for all campus facilities. These documents help support many campus entities and initiatives including, but not limited to, Telecommunications, Maintenance Management, Institutional Research & Planning, and Geographic Information Systems (GIS).

In order to support FMD in the process of generating such documents, a well-defined set of Computer-Aided Design (CAD) standards are required to maximize efficiencies and usability. Architects/Engineers/Contractors (AEC) delivering documentation to Duke must ensure these standards are reviewed, understood, and followed by those responsible for preparing electronic drawings. Enclosed is a CAD Standard Quality Assurance checklist, provided in Appendix B, to assist in the production of qualified documents. This checklist ensures the AEC firm has met the format requirements set forth in this document. If received documentation does not comply with the following standards, final payment may be delayed until documents conform to requirements.

Duke requires adherence to the latest version of the AIA CAD Guidelines found in the most current addition of the United States National CAD Standard® (NCS) in addition to the Duke requirements outlined in this document. For additional detail beyond what is outlined herein, please refer to the [NCS](#) for guidance.

### 2.1 Document Type Deliverables

#### 2.1.1 *As-Designed Record Drawings*

As-designed record drawings are defined by Duke as the record of everything the Architect designed for the project, and include the original construction documents plus all construction change directives and minor changes in the work.

#### 2.1.2 *As-Constructed Record Drawings*

As-constructed record drawings are defined by Duke as drawings that are prepared by the Architect and reflect on-site changes the Contractor noted in the red-line drawings. They are often compiled as a set of on-site changes made for the Owner per the Owner-Architect contract.

\*Note: The definition of red-line drawings, commonly known as as-builts, may differ depending on the organization, but Duke defines red-line drawings as drawings that are prepared by the contractor, in red ink, all changes from the as-designed record drawings. This set of drawings depicts the actual conditions of the completed construction “as it was built.” Red-line drawings are delivered to the Architect by the Contractor upon completion of the work, and are integrated by the Architect into the as-constructed record drawings.

### 3 CAD Drawing Production

The intent for a standard CAD drawing production is to allow a multitude of personnel to review, revise, share, maintain, and print archived projects. FMD has adopted the most current version of the AIA CAD Guidelines found in the latest addition of the United States National CAD Standard® (NCS). It is required that all AEC firms providing documentation to Duke University adopt these guidelines as well as implement the predefined standards described herein.

#### 3.1 File Format and Setup

##### 3.1.1 Electronic File Format

All as-constructed record drawings must be submitted to Duke in the most current version of AutoCAD® software at time of submission; other formats are unacceptable without prior consent from FMD. All drawings prepared must be submitted in a DWG format.

##### 3.1.2 Scale, Units, and Tolerance

All CAD drawing models should be drafted at full scale in architectural units, such that one drawing unit equals one inch. Tolerance for construction drawings are implicit within professional service contracts.

DWG Scale	Scale Factor	1/16"	3/32"	1/8"	3/16"	1/4"	1/2"	3/4"	1"
1/16" = 1'-0"	192	12"	18"	24"	36"	48"	96"	144"	192"
3/32" = 1'-0"	128	8"	12"	16"	24"	32"	64"	96"	128"
1/8" = 1'-0"	96	6"	9"	12"	18"	24"	48"	72"	96"
1/4" = 1'-0"	48	3"	4.5"	6"	9"	12"	24"	36"	48"
1/2" = 1'-0"	24	1-1/2"	2.25"	3"	4.5"	6"	12"	18"	24"
3/4" = 1'-0"	16	1"	1.5"	2"	3"	4"	8"	12"	16"
1" = 1'-0"	12	3/4"	1-1/8"	1-1/2"	2-1/4"	3"	6"	9"	12"
1-1/2" = 1'-0"	8	1/2"	3/4"	1"	1-1/2"	2"	4"	6"	8"
3" = 1'-0"	4	1/4"	3/8"	1/2"	3/4"	1"	2"	3"	4"

Figure 3.1.3 – Text Scale Factor for Common Architectural Drafting Scales

##### 3.1.3 Fonts and Text Styles

Duke requires the use of only native AutoCAD® fonts, linetypes, and hatch patterns. These are standard support features installed as part of a standard AutoCAD® installation. Postscript and custom fonts, linetypes, and hatch patterns, including those provided by 3<sup>rd</sup> party software, shall not be used. This may result in content discrepancies and loss of data information.

##### 3.1.4 Blocks

Duke is currently not using or enforcing the use of any particular blocks or libraries. However, Duke requires that the following general rules be used when handling block entities:

- All entities within a block must be created on layer 0
- Drawing entities translated into blocks from non-AutoCAD® systems must revert to layer 0 when exploded.
- File translation from other systems which result in wall blocks within the DWG file are unacceptable.

### 3.1.5 Standard Paper Sizes

In an effort to maintain consistency between record drawings, all submitted documents must be produced to the following standard sizes: 24x36 (ARCH D) or 30x42 (ARCH E – preferred size).

## 3.2 Title Blocks

Each CAD file submitted to FMD shall have only one title block. If using paper space, the title block shall be placed with its lower left hand corner point inserted at a coordinate location of: 0,0,0. Official Duke title blocks are available in AutoCAD® format for use for project drawings and is preferred for As-Constructed Record Drawings. These are available from the Duke FMD website: [Forms & Instructions](#). The drawing's title block shall contain the following information:

### 3.2.1 Required Project Information

- AEC Firm Name – Consultant responsible for producing the drawings
- Project Name – As specified by Duke
- Building Number – As specified by Duke
- Building Name – Only list if project name doesn't include already
- Duke Project Number – As specified by Duke

### 3.2.2 Required Sheet Information

- Sheet Title – Drawing content; e.g. floor plan, section, detail, etc.
- Sheet ID – Adhere to NCS Layer Name Format, available from the Duke FMD website: [Forms & Instructions](#)
- Original Issue Date – Shall remain the same once drawings have been issued
- Revision History – As applicable
- Drawing Phase – Schematic Design, Design Development, Construction Drawings, etc.
- Drawing Scale – Representing the intended plot scale of the drawing with titleblock
- North Arrow - Indicating the orientation of drawing
- Include Disclaimer – “These drawings and the designs here illustrated are the sole property of Duke University and may not be reproduced in whole or in part without express written permission”
- List of Critical Systems Represented in Drawing – As Applicable to MEP Deliverables pertaining to CSB

## 3.3 Drawing Environment

### 3.3.1 External Reference File (Xref) and Imported Image Files (JPGs, BMPs, PNGs, etc.)

Duke University will **NOT** accept CAD drawing submissions that reference external source drawing files (Xref). Upon project completion and prior to drawing delivery to Duke all externally referenced data sources that were used during the CAD drawing production should be bound within a single drawing file, including the Titleblock and any image files. The resulting self-contained drawing file is an acceptable deliverable to Duke.

### 3.3.2 Model Space and Paper Space

AutoCAD® drawings created outside of Duke sometimes contain more than one drawing sheet per file. While this may facilitate the production of construction documents, it will impede the archival process and create content discrepancies. Duke requires that each CAD file submitted at project closeout shall contain only one variation of the drawing, at full scale, in model space and one titleblock in paper space drawn at 1:1. Alternate design considerations, collaboration ideas, multiple variations of design and other work that is not needed or not meant to be submitted shall NOT be included within

the file. All AutoCAD® drawings shall be purged of empty, unused, or nonessential drawing data prior to submittal. This includes all unused layers, linetypes, blocks, fonts, and entities.

- In addition, the following practices should NOT be followed:
- Do not place or draw model related blocks, tags, and objects in paper space
- Do not dimension model space objects in paper space
- Do not rotate the User Coordinate System (UCS), i.e. XY plane

### 3.4 Layering

Duke adopted the same layer name schema as the AIA CAD Standards provided by the NCS for certain categories. Figure 3.4 lists which disciplines have been adopted and which were not. Please refer to the [NCS](#) for a complete list of discipline designators, major and minor groups.

Adopted AIA Layer Naming	Non-Adopted AIA Layer Naming
Architectural	Civil
Electrical	Landscape
Mechanical	Site
Plumbing	Surveying
Structural	

Figure 3.4 – Adopted and Non-adopted disciplines

#### 3.4.1 Summary of Best Practices

- Use the minimum number of layers necessary to adequately separate entities in each drawing. The number of layers may vary depending on the project, but should not contain extraneous, redundant, or overly detailed layer names
- Purge each drawing of empty, unused, or nonessential layers prior to submittal
- If project is designed in phases, merge together all layers with the same entity into one layer.

#### 3.4.2 Layer Name Formatting

The NCS layer naming convention, followed by Duke, is systematized in a hierarchical format. This format allows for expansion and customization. Layer names are defined into four data fields: discipline designator, major group, two minor groups, and a status field. For additional detail regarding standard layer name formatting, please refer to [NCS](#) for guidance.

A	-	W	A	L	L	-	F	U	L	L	-	T	E	X	T	-	N
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Figure 3.4.1 – Layer Name Data Fields

##### 3.4.2.1 Discipline Designator

The discipline code designator is a required one or two-character field identifying the category of subject matter contained on the specific layer. See figure 3.4.1.1. for a list of Level 1 Discipline Designators.

Level 1 Discipline Designators			
A	Architectural	L	Landscape
C	Civil	M	Mechanical

E	Electrical	P	Plumbing
G	General	S	Structural

Figure 3.4.1.1 – Level 1 Discipline Designators

### 3.4.2.2 Major Group

The Major Group is a required four-character field that identifies a major building system, such as doors, walls, windows, etc. Major groups are classically grouped with specific discipline designators. However, it is possible to combine major group codes with any of the discipline designators listed. See figure 3.4.1.2 for a typical layer name listing a major group.

A	-	W	A	L	L
---	---	---	---	---	---

Figure 3.4.1.2 – Typical Major Group

### 3.4.2.3 Minor Group

The Minor Group is an optional four-character field to further define the Major Group. For example, A-WALL-FULL denotes Architectural-Wall-Full Height. You may need an additional minor group to further describe the entities within the layer. See figures 3.4.1.3.1 for a typical layer name showing one minor group.

A	-	W	A	L	L	-	F	U	L	L
---	---	---	---	---	---	---	---	---	---	---

Figure 3.4.1.3.1 – Typical layer name showing one optional Minor Group

A	-	W	A	L	L	-	F	U	L	L	-	T	E	X	T
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Figure 3.4.1.3.2 – Typical layer name showing two optional Minor Groups

### 3.4.2.4 Status Field

The Status Field is an optional single-character field that denotes the work status or construction phase. Since drawings submitted at close-out are As-Constructed Record Drawings, this field should be used to distinguish new construction from existing. See figure 3.4.1.4.1 for a typical layer name showing a status field.

A	-	W	A	L	L	-	F	U	L	L	-	T	E	X	T	-	N
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Figure 3.4.1.4.1 – Typical layer name showing optional Status Field

Status Field Codes			
A	Abandoned	N	New work
D	Existing to demolish	T	Temporary work
E	Existing to remain	X	Not in contract
F	Future Work		

Figure 3.4.1.4.2 – Status Field Codes

### 3.4.3 Attributes (Colors, Linetypes, Pens, etc.)

Attributes that have not been pre-defined by FMD may be assigned at the discretion of the client following the exact AIA CAD Layering Guidelines found in the latest version of the National CAD Standard® (NCS) guidelines.

3.4.3.1 Colors

Duke recommends the use of specific colors for the layers and annotation layers most often used to assist in program assessment, space documentation and future project development. The color assignment of these layers can be found in the *Standard Layer Listing*, figure 3.4.4. All other layers may have their colors assigned at the discretion of the client.

3.4.3.2 Linetypes

The default linetype of each layer is typically CONTINUOUS unless otherwise specified. All other layers may have their linetypes assigned at the discretion of the client.

3.4.3.3 Pen Weight

Figure 3.4.2.3 is a list of pen weight assignments which should maximize the printed clarity of drawings conforming to the color assignments. Other pen weights may be assigned at the discretion of the client, include CTB file at submission.

Pen	Color	Weight (mm)	
		Architectural	MEP (CSB Deliverables)
1	Red	0.13 mm	0.50 mm
2	Yellow	0.18 mm	0.50 mm
3	Green	0.25 mm	0.50 mm
4	Cyan	0.35 mm	0.50 mm
5	Blue	0.13 mm	0.50 mm
6	Magenta	0.25 mm	0.50 mm
7	White/Black	0.35 mm	0.35 mm
8	Gray	0.13 mm	0.13 mm
9	Light Gray	0.10 mm	0.10 mm
15	Brown	0.18 mm	0.50 mm
30	Orange	0.35 mm	0.50 mm

Figure 3.4.2.3 – Pen Weight Table Options

3.4.4 Standard Layer Listing

The following layer list is an example of commonly used NCS – AIA layer names along with additional Duke specific layer names (marked with a \*). Where Duke specific layer name differs from the NCS – AIA CAD layer name, Duke naming shall take precedent. Other layer names may be used at the discretion of the client following the exact AIA CAD Layering Guidelines found in the latest version of the National CAD Standard® ([NCS](#)) Guidelines.

Standard Layer List			
	Name	Description	Color
<b>General Layers</b>			
	G-ANNO-KEY	Key Plan	
	G-ANNO-MATC	Matchlines	
	G-ANNO-NPLT	Non-plotting Graphic Information	
	G-ANNO-TEXT	Text	
*	G-ANNO-TTLB	Border and Titleblock	7-white
*	G-ANNO-TTLB-LOGO	Duke Logo	176-Duke Blue
*	G-ANNO-TTLB-TEXT	Titleblock Text	7-white
<b>Standard Architectural Layers</b>			
	A-ANNO-DIMS	Dimensions	7-white
	A-ANNO-NOTE	Notes	7-white
*	A-AREA	Area Calculation Boundary Lines	4-cyan
*	A-AREA-IDEN	Room Numbers, Tenant Identifications, Area Calculations	7-white
*	A-AREA-PATT	Area Hatching	9-gray
*	A-CLNG	Ceiling: Information	1-red
*	A-COLS	Columns	4-cyan
*	A-DOOR	Doors	30-orange
*	A-DOOR-IDEN	Doors: Numbering, Hardware Group, etc.	7-white
*	A-DOOR-SWNG	Doors: Swing	5-blue
*	A-EQPM	Equipment	15-brown
	A-EQPM-OVHD	Equipment: Overhead	8-gray
	A-EQPM-IDEN	Equipment: Identification	7-white
	A-FLOR	Floor Information	2-yellow
*	A-FLOR-CSWK	Floor: Casework, Cabinets, Counters	6-magenta
*	A-FLOR-EVTR	Floor: Elevator Cars and Equipment	3-green
*	A-FLOR-FIXT	Floor: Fixtures (plumbing)	5-blue
*	A-FLOR-HRAL	Floor: Handrails	2-yellow
*	A-FLOR-LEVL	Floor: Level Changes (ramps, pits, depressions)	3-green
*	A-FLOR-OVHD	Floor: Overhead	8-gray
*	A-FLOR-PATT	Floor: Pattern and Hatchings	5-blue
*	A-FLOR-STRS	Floor: Stairs and Ladders	3-green
*	A-FLOR-TPTN	Floor: Toilet Partitions	5-blue
*	A-FURN	Furnishings	8-gray
*	A-FURN-FIXD	Furnishings: Fixed	8-gray
*	A-FURN-SEAT	Furnishings: Seating	8-gray
*	A-GLAZ	Glazing	3-green
*	A-GLAZ-SILL	Glazing: Window Sills	2-yellow
*	A-GLAZ-IDEN	Glazing: Window Numbering	7-white
*	A-ROOF	Roof	1-red
*	A-ROOF-OTLN	Roof: Outline	1-red
*	A-WALL-EXTR	Walls: Full Height – Exterior	4-cyan
*	A-WALL-INTR	Walls: Full Height – Interior	4-cyan

Standard Layer List			
	Name	Description	Color
*	A-WALL-MTRL	Walls: Finish Materials (gypsum, architectural finishes, etc.)	5-blue
*	A-WALL-PATT	Walls: Hatching/Poché	9-gray
*	A-WALL-PRHT	Walls: Partial Height	6-magenta
Critical Mechanical Layers			
*	M-CWTR-PIPE	Chilled Water System: Supply/Return Piping	5-blue
	M-CWTR-EQPM	Chilled Water System: Equipment	5-blue
	M-CWTR-IDEN	Chilled Water System: Identification	5-blue
	M-CWTR-CNDS-PIPE	Chilled Water System: Condensate Piping	5-blue
	M-CNDW-PIPE	Condenser Water System: Piping	15-brown
	M-CNDW-EQPM	Condenser Water System: Equipment	15-brown
	M-CNDW-IDEN	Condenser Water System: Identification	15-brown
*	M-HVAC-EQPM	HVAC System: Equipment	7-white
	M-HVAC-EQPM-IDEN	HVAC System: Equipment Identification	7-white
*	M-HVAC-EXHS	HVAC System: Exhaust Air	30-orange
	M-HVAC-EXHS-EQPM	HVAC System: Exhaust Air Equipment	30-orange
	M-HVAC-EXHS-IDEN	HVAC System: Exhaust Air Identification	30-orange
*	M-HVAC-RETN	HVAC System: Return Air	4-cyan
	M-HVAC-RETN-EQPM	HVAC System: Return Air Equipment	4-cyan
	M-HVAC-RETN-IDEN	HVAC System: Return Air Identification	4-cyan
*	M-HVAC-SPLY	HVAC System: Supply Air	3-green
	M-HVAC-SPLY-EQPM	HVAC System: Supply Air Equipment	3-green
	M-HVAC-SPLY-IDEN	HVAC System: Supply Air Identification	3-green
*	M-HWTR-PIPE	Hot Water Heating System: Supply/Return Piping	1-red
	M-HWTR-EQPM	Hot Water Heating System: Equipment	1-red
	M-HWTR-IDEN	Hot Water Heating System: Identification	1-red
*	M-PROC-CWTR	Process System: Process Chilled Water Supply/Return Piping	5-blue
	M-PROC-CWTR-IDEN	Process System: Process Chilled Water Identification	5-blue
*	M-STEM	Steam System	6-magenta
*	M-STEM-EQPM	Steam System: Equipment	6-magenta
	M-STEM-CNDS	Steam System: Condensate Piping	6-magenta
*	M-STEM-HPIP	Steam System: High-Pressure Steam	6-magenta
	M-STEM-HPIP-IDEN	Steam System: High-Pressure Steam Identification	6-magenta
*	M-STEM-LPIP	Steam System: Low-Pressure Steam	6-magenta
	M-STEM-LPIP-IDEN	Steam System: Low-Pressure Steam Identification	6-magenta
*	M-STEM-MPIP	Steam System: Medium-Pressure Steam	6-magenta
	M-STEM-MPIP-IDEN	Steam System: Medium-Pressure Steam Identification	6-magenta
	M-STEM-VENT	Steam System: Vent Piping	6-magenta
Critical Electrical Layers			
*	E-POWR	Power	1-red
*	E-POWR-EQPM	Power: Equipment	1-red
*	E-POWR-EQPM-CRIT	Power: Equipment: Critical	1-red
*	E-POWR-IDEN	Power: Identification	1-red

Standard Layer List			
	Name	Description	Color
*	E-EMER-POWR	Emergency Power	6-magenta
*	E-EMER-POWR-EQPM	Emergency Power: Equipment	6-magenta
*	E-EMER-POWR-IDEN	Emergency Power: Identification	6-magenta
Critical Plumbing Layers			
*	P-DOMW-CPIP	Domestic Water Systems: Cold Water Piping	5-blue
*	P-DOMW-CPIP-IDEN	Domestic Water Systems: Cold Water Identification	5-blue
*	P-DOMW-HPIP	Domestic Water Systems: Hot Water Piping	1-red
*	P-DOMW-HPIP-IDEN	Domestic Water Systems: Hot Water Identification	1-red
*	P-DOMW-EQPM	Domestic Water Systems: Equipment	7-white
*	P-DOMW-EQPM-IDEN	Domestic Water Systems: Equipment Identification	7-white
	P-FIXT	Plumbing Fixtures (Toilets, Sinks, etc.)	
	P-FIXT-IDEN	Plumbing Fixtures Identification	
	P-GAS-NG	Gas Systems: Natural Gas Piping	
	P-GAS-NG-EQPM	Gas Systems: Natural Gas Equipment	
	P-GAS-NG-IDEN	Gas Systems: Natural Gas Identification	
*	P-LAB-SSWR	Lab Waste Piping	15-brown
*	P-LAB-SSWR-IDEN	Lab Waste Identification	15-brown
*	P-LAB-AIR-PIPE	Lab Air Piping	4-cyan
*	P-LAB-AIR-IDEN	Lab Air Identification	4-cyan
*	P-LAB-VAC	Lab Vacuum Piping	30-orange
*	P-LAB-VAC-IDEN	Lab Vacuum Identification	30-orange
	P-SSWR-EQPM	Sanitary Sewer: Equipment	
	P-SSWR-IDEN	Sanitary Sewer: Identification	
	P-SSWR-PIPE	Sanitary Sewer: Piping	
	P-SSWR-VENT	Sanitary Sewer: Vents	
*	P-WTR-DI	Water Systems: Deionized Water	3-green
*	P-WTR-DI-IDEN	Water Systems: Deionized Water Identification	3-green
*	P-WTR-RO	Water Systems: Reverse Osmosis Water	3-green
*	P-WTR-RO-IDEN	Water Systems: Reverse Osmosis Water Identification	3-green
*	P-WTR-NPHW	Water Systems: Non-Potable Hot Water	
	P-WTR-NPHW-IDEN	Water Systems: Non-Potable Hot Water Identification	
	P-WTR-NPCW	Water Systems: Non-Potable Cold Water	
	P-WTR-NPCW-IDEN	Water Systems: Non-Potable Cold Water Identification	
	P-WTR-PW	Water Systems: Potable Water	
	P-WTR-PW-IDEN	Water Systems: Potable Water Identification	
Standard Structural Layers			
*	S-COLS	Columns	
*	S-GRID	Column Grid	
*	S-GRID-DIMS	Column Grid Dimensions	
*	S-GRID-IDEN	Column Grid Identification	

Figure 3.4.4 – Standard Layer List

## 4 MEP Critical Systems Building Documentation

All deliverables and processes discussed here are supplemental to those outlined in the Owner-Consultant Agreement contract. Projects within figure 4.0 must adhere to the following section along with any items listed in Appendix C. Documentation includes Schematic/ 1-line diagrams, floorplans, along with gathering equipment data for use in Duke’s EAM database system.

Critical Systems Building List			
Building #	Building Name	Building #	Building Name
7758	Biological Sciences Building	7776	Levine Science Research Center
7772	Bio-Sci Greenhouses	7198	Nashar Art Museum
7923	Bookhut Laboratory	7922	Ocean Sciences Teaching Center
7735	Fitzpatrick (CIEMAS)	7704	Perkins Library
7780	Free Electron Laser Lab	7749	Physics Building
7738	French Family Science Center	7771	Phytotron Building
7765	Gross Hall	7767	Triangle University Nuclear Lab
7764	Lemur Center		

Figure 4.0 – Critical Systems Building List

### 4.1 Documentation Requirements

#### 4.1.1 Floorplans

- a. Document graphically, using the latest version of AutoCAD®, all equipment listed in *figure 4.3.2*. Field verify the approximate routing of equipment connections within the critical systems. Equipment connections shall be represented with a single-line.
- b. All equipment to be labeled with nomenclature provided by Duke.
- c. Abbreviations, symbols and line types shall utilize the latest version of ASHRAE®.
- d. Duct and pipe sizes not required.
- e. Each system and all text shall be drawn on separate layers following Duke’s requirements outlined herein, in addition to the United States National CAD Standard® ([NCS](#)).
- f. All floors shall be separated into one floor per AutoCAD® file.
- g. Titleblock will be provided by Duke, sheet size dependent on building scaled at 1/4” = 1’-0”.

#### 4.1.2 Schematic / 1-Line Diagrams

- a. Document each system individually
- b. Diagrams shall be formatted to fit one system per 24x36 sheet
- c. Abbreviations, symbols and line types formatted to the latest version of ASHRAE®

#### 4.1.3 Critical Systems Documentation List

MEP Firm will be required to produce complete documentation of predefined critical systems. This includes physical inspection and documentation of the systems listed in *figure 4.3.2* of this document.

Critical Systems Documentation List					
Discipline	System	Schematic/ 1-Line	Floorplan	Field Verify	Equipment Required
Mechanical	Supply/Return	✓	✓	✓	AHU, System Fans, Terminal Equipment
	Exhaust Air: Lab	✓	✓	✓	System Fans, Terminal Equipment
	Exhaust Air: Non-Lab	✓	✓	✓	System Fans, Terminal Equipment
	Chilled Water	✓	✓	✓	Building Isolation Valves, Zone Isolation Valves, AHU, Terminal Equipment
	Hot Water	✓	✓	✓	Heat Exchangers, Zone Isolation Valves, AHU, Terminal Equipment, Pumps
	Steam	✓	✓	✓	Building Isolation Valves, PRV, Heat Exchanger, AHU, Steam Utilization Equipment
	Process Cooling	✓	✓	✓	Heat Exchanger, Pumps, Zone, Isolation Valves, Utilization Lab Locations, Cold Boxes
	Smoke Removal		✓	✓	System Components (Fans, Dampers, Doors, etc.)
Electrical <sup>1</sup>	Emergency Power/ Standby	✓	✓	✓	All major equipment likely to contribute energy to the system (Transformers, generators, motors 25HP or greater, chillers, boilers, AHU's, etc.)
	Normal Power	✓	✓	✓	
Plumbing	Domestic Water	✓	✓		
	RO/DI	✓	✓		
	Lab Gases	✓	✓		
	Control Compressed Air	✓	✓		
Notes	<sup>1</sup> Electrical data provided by Duke from SKM Model for existing buildings				

Figure 4.3.2 – Critical Systems Documentation List

4.1.4 Data Supplied by Duke for Existing Buildings

- a. Schematic/ 1-Line Diagrams (as available)
- b. Floorplans (as available)
- c. Existing as-built information (as available)
- d. Equipment labeling nomenclature
- e. Assistance during field verifications

4.1.5 Documentation Deliverables

Refer to section 5 of this documents, *CAD Drawings Closeout Documentation*, for further details.

## 5 CAD Drawings Closeout Documentation

### 5.1 Translating from Other CAD Software

Duke acknowledges that many of its AEC firms do not use the same software to produce drawings and models for their projects. However, Duke expects that service providers who work with other file formats submit DWG formatted CAD files upon project closeout. These files must fully conform to the latest AIA CAD Guidelines obtained from the United States National CAD Standard® (NCS) in addition to the Duke requirements outlined herein. These files shall have no significant loss of drawing entities or project data that can result from standard CAD file translation procedures.

It is recommended that a thorough translation/conversion test procedure be conducted before the drawing development phase of the project. This test will identify file conversion issues early on and allow for corrective measures to be taken prior to the project closeout. All DWG files and CAD drawing entities submitted at the end of a project must be able to be manipulated using standard AutoCAD® drafting procedures. Non-compliance with this policy may result in the rejection of CAD files submitted at project closeout in addition to delayed final project payment.

### 5.2 Sheet Identification

#### 5.2.1 File Identification and Naming Conventions

Duke requires that for each sheet submitted as project deliverable there is a corresponding DWG file. The sheet and the digital files should follow the same naming convention as described in the latest version of the NCS® Drawing Set Organization Standard. This is available for download from the Duke FMD website: [Forms & Instructions](#).

#### 5.2.2 Standard Sheet Identification

The sheet identifier consists of three components: the discipline designator, the sheet type designator, and the sheet sequence number.

##### 5.2.2.1 Discipline Designator

The discipline designator consists of one alphabetical character and a hyphen or two alphabetical characters. The designator allows for the user to easily identify the category of subject matter contained within the file. Standard layer codes used for the discipline designator are listed in section 3.4 - Layers of this document.

##### 5.2.2.2 Sheet Type Designator

The sheet type designator is a single digit that classifies the sheet type and allows the user to identify the type of information presented in the drawing. See figure 4.3.2.2 for a list of standard sheet type designators.

Sheet Type Designator	
0	General (Symbols, Legends, Notes, etc.)
1	Floor Plans (Horizontal Views)
2	Elevations (Vertical Views)
3	Sections (Wall Sections)
4	Large-Scale Views (Enlarged Plans, Elevations, etc.)
5	Details
6	Schedules & Diagrams
7	User Defined (for types that don't fall in other categories)

8	User Defined (for types that don't fall in other categories)
9	3D Representations (Isometrics, Perspectives, Photographs)

Figure 4.3.2.2 – Sheet Type Designators

### 5.2.2.3 Sheet Sequence Number

The sheet sequence number is a double digit number in order from 0 through 99.

Example: First Floor Plan – A1.1

### 5.2.3 File Name

Desired file naming convention for Duke:

File Name: 0000\_A1.1 – Sheet Title.dwg

Convention: [Duke Building #]\_[discipline][sheet designator].[Sheet Sequence #]-[Sheet Title].[extension]

## 5.3 Drawing Closeout Delivery

To ensure the integrity of the electronic drawing set upon delivery to Duke:

- Ensure the drawings adhere to the guidelines presented in this document.
- All documentation submitted to Duke FMD must be accompanied by the following:
  - Completed Electronic File Index – A clear catalog of information to assist in the archival process
  - Include AutoCAD® plot configurations (CTB file)
  - Signed Quality Assurance CAD Standard Checklist - ensures the AEC firm has met the format requirements
  - Signed Quality Assurance MEP Critical Systems Checklist – CSB projects only
- Submit two (2) sets of digital drawings in total. Files must be included on a portable storage device (i.e. CD/DVD, thumbdrive, etc.) or uploaded to a designated FTP site:
  - One (1) set of DWG files; purged of empty, unused, or nonessential drawing data prior to submittal
  - One (1) set of Adobe® PDF files

### 5.3.1.1 AutoCAD® Delivery Requirements

One (1) full set of AutoCAD® files. This set must meet all the standards set forth in this guideline in addition to the latest AIA CAD Standards obtained from the United States National CAD Standard® ([NCS](#)).

### 5.3.1.2 PDF Delivery Requirements

One (1) set of full size Adobe PDFs. Each sheet must be saved as a separate file with the name of these files corresponding to its respective DWG file. Multipage PDFs will not be accepted.

## 5.4 Timeline of Deliverables

**The timeline for completion and submission of the record drawings will be three months after substantial completion** for buildings. As per the AIA Document A201-1997 - General Conditions of the Contract for Construction, substantial completion is defined as follows:

“The stage in the progress of the Work where the Work or designated portion is sufficiently complete in accordance with the Contract Documents so that the Owner can occupy or utilize the Work for its intended use.”

6 Appendices

**A. ELECTRONIC FILE INDEX ..... A**

**B. QUALITY ASSURANCE CAD STANDARD CHECKLIST .....B**

**C. QUALITY ASSURANCE MEP CRITICAL SYSTEMS CHECKLIST .....C**



## B. Quality Assurance CAD Standard Checklist

All CAD drawings delivered to Duke University at closeout must be accompanied by this Quality Assurance CAD Standard Checklist. This signed and submitted checklist ensures the AEC firm has met the format requirements set forth in the CAD Standards Guideline provided by Duke University. If received documentation does not comply with the following standards, final payment may be delayed until documents conform to requirements.

### File Format and Setup

- Electronic File Format
  - AutoCAD® and Adobe® PDF
- Scale, Units, and Tolerance
  - Full Scale
  - Architectural Units
  - Tolerance within Standard of Care
- Fonts and Text Styles
  - No Post Script Fonts
  - Native AutoCAD fonts, linetypes, and hatch patterns
- Block Definitions – Created on layer 0
- Paper Size – 24x36 or 30x42 (preferred size)

### Titleblock

- One per File
- Inserted in Paper Space
- Insertion Coordinate of (0,0,0)
- Required Project and Sheet Information

### Layers

- Comply with the AIA and Duke CAD Layer Standards
- Layer Naming Formatting
- Attributes (Colors, Linetypes, Pen Weight)

### Drawing Environment

- Xref and Image File Policy
- Model Space and Paper Space Policy
  - Purged of empty, unused, or nonessential drawing data
  - If project is designed in phases, merge together all layers with the same entity into one layer.
  - One variation of the drawing, at full scale, in model space
  - One titleblock, at 1:1, in paper space

### CAD Drawings Closeout Documentation

- Translating from Other CAD Software
  - Full AutoCAD® Compliance
  - Translation/Conversion Test
  - No loss of project data
- MEP Critical System Deliverable?
  - Yes; include Q/A CSB Checklist
  - No

### Electronic Deliverables

- Duke Naming Convention
- Drawings Adhere to AIA and Duke CAD Standards
- Electronic File Index Filled Out and Included
- Submission – one (1) full set of DWGs and one (1) full set of PDFs.
- File Delivery – CD/DVD, Thumbdrive, or uploaded to an FTP Site

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Printed Name of AEC Firm Representative

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Signature & Date of AEC Firm Representative

## C. Quality Assurance MEP Critical Systems Checklist

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All electronic deliverables associated with a Critical Systems building must be accompanied by this Quality Assurance MEP Critical Systems Checklist. This signed and submitted checklist ensures the Engineering firm has met the format requirements pertaining to Critical Systems Deliverables set forth in the CAD Standards Guideline provided by Duke University. If received documentation does not comply with the following standards, final payment may be delayed until documents conform to requirements.

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### MEP Critical Systems CAD Standards

- Follow general CAD standards set forth in Duke's CAD Standard Guideline

#### File Format and Setup

- Latest version of AutoCAD®
- Abbreviations, symbols, and line types formatted to the latest version of ASHRAE®

#### Layers

- Comply with Duke and the AIA CAD Layer Standards
- Standard MEP Layer Naming Convention
  - Each Critical System on Separate Layers
  - Text Pertaining to each Critical System on Separate Layers
  - Each System Broken into Separate Color Attributes

#### Drawing Environment

- One Floor per File
- Purged of empty, unused, or nonessential drawing data
- If project is designed in phases, merge together all layers with the same entity into one layer.

### Drawing Requirements

- Floorplans
  - All Systems in One-Line Format
  - Field Verified
  - Duke Equipment Nomenclature
  - Approximate routing indicated
  - Flow path indicated
- Schematic/ 1-Line Diagrams
  - One system per 24x36 sheet
  - Each system documented separately

### CSB Closeout Documentation

- Scaled Floorplans
- Diagrams
- Submission – one (1) full set of DWGs and one (1) full set of PDFs.
- File Delivery – CD/DVD, Thumbdrive, or uploaded to an FTP Site

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Printed Name of AEC Firm Representative

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Signature & Date of AEC Firm Representative