SMACNA CAD STANDARD

**SHEET METAL AND AIR CONDITIONING CONTRACTORS'
NATIONAL ASSOCIATION, INC.**

SMACNA CAD STANDARD

SECOND EDITION – JULY 2001

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION, INC.
4201 Lafayette Center Drive
Chantilly, VA 20151–1209

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by

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION, INC.

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FOREWORD

The SMACNA CAD STANDARD (SCS), formerly called *CADD Symbols and Layering Guidelines* in its first edition, embraces the idea that computer-aided design (CAD) has become indispensable to the architecture/ engineering/ construction (AEC) industry. Not only has CAD software improved drafting efficiency and the overall productivity of the construction professional, but now building owners are realizing the potential of automated controls and electronic record keeping and are requesting data in electronic format from construction professionals.

Now that they have learned to communicate with the computer, many designers and builders are using computers to improve communications with each other. In order to share electronic information efficiently, it's essential that all parties speak the same language. For members of the endorsing organizations, it's important that the mechanical, plumbing, and fire protection information be labeled and located consistently in CAD files so that it is easily found and manipulated. For building owners and design professionals, it's important that such data be consistently stored within their own CAD files in accord with a mutually agreed protocol or standard. To ensure consistency it is important to organize data into predefined "layers", to apply identical graphic symbols to components, and to use consistent terminology and abbreviations.

SCS is designed to encourage consistency by building upon the second edition of the *National CAD Standard* (NCS) published by the National Institute of Building Sciences in 2001. NCS incorporates the efforts of the American Institute of Architects (AIA) and its *CAD Layer Guidelines* as well as the Construction Specifications Institute (CSI) and its *Uniform Drawing System*. As an organization with contributing members on the NCS Committee, SMACNA is committed to improving electronic communication between members of the AEC community and the overall quality of their work.

In this current edition of SCS, SMACNA has extended NCS by drawing upon the considerable experience of its own CADD Task Force. SCS articulates the CAD standards that will enable SMACNA members and the rest of the AEC community to apply CAD effectively to mechanical, fire protection, and plumbing design and construction.

This document is available in electronic format by accessing http://www.smacna.org on the Internet.

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CHAPTER 1

INTRODUCTION

1.1 HOW TO USE THIS PUBLICATION

This publication is designed to be an easy to use quick reference guide. The information it contains is organized and presented in three discrete categories: layers, abbreviations, and symbols.

Chapter 2 describes standard layers based upon the National CAD Standard (NCS) which include many new additions introduced by members of SMACNA's CADD Task Force who participated on the NCS Committee. This flexible standard is well documented and provides several concrete examples of efficient layer use.

Chapter 3 provides a list of standard abbreviations which are a combination of the abbreviations found in SMACNA's first edition of the *CADD Symbols and Layering Guidelines* and the standard abbreviations listed in the Construction Specification Institute's *Uniform Drawing System*, part of NCS.

Chapters 4 though 9 list standard drafting symbols, grouped by construction component category. These symbols come from a variety of sources and are now assembled together into one comprehensive source to be used by the mechanical trades. All of the symbol blocks in this publication may be downloaded from http://www.smacna.org.

Experienced CAD users and novices alike can turn to Appendix A for a more complete overview of the requirements for implementing an office CAD standard. Useful checklists and a CAD document submittal form are provided in the remaining appendices.

1.2 READER FEEDBACK

The layers, abbreviations, symbols, and protocols described in this book are part of an evolving standard. Users are encouraged to offer comments and suggestions after they have reviewed and used this material in practice. Please send your feedback to:

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CHAPTER 2

LAYERS

2.1 WHAT ARE CAD LAYERS?

One of the best ways to understand CAD layers is to imagine drafting manually on many stacked sheets or layers of transparent acetate. Starting at the bottom of the pile is a layer of acetate on which only the building walls are drawn. Following an office standard, the drafter might place another acetate layer on top of that, and while seeing through to the wall layer, draw the door swings. Another layer might contain only the air conditioning equipment. When all the layers are stacked and aligned, a complete, if complex and crowded, picture of the entire building is viewed. Selected layers can be removed and recombined to give an uncluttered view of items of particular interest. For example, an HVAC contractor might select only the sheets with the walls and the air conditioning equipment. A construction supervisor might want to examine the piping and ductwork in isolation to ensure that there are no interferences that will create costly conflicts during construction.

CAD systems manipulate layers of information faster than any manual drafting process. Using CAD software, drafters can turn layers on and off, controlling which layers are displayed and edited at any given time, for any given purpose. When properly used, CAD systems generate drawings that are simpler and easier to read. For example, a complex job like a hospital may have so much mechanical work that to display it all in one drawing would be completely illegible. Although the drawing data may all reside in a single file for computer storage efficiency, a crew installing terminal units doesn't necessarily need to see all of the ductwork and piping. They may only need a drawing on the job site that displays only the wall and terminal unit layers. CAD systems provide the means to display only the most relevant information.

2.2 WHY ARE CAD LAYERS IMPORTANT?

Adhering to a consistent and mutually well understood CAD layer standard gives professionals a common communications vocabulary which is vital today since so many construction drawings and so much data is shared electronically. Without a CAD layer standard, sharing drawings between two CAD systems or simply trying to read electronic drawings prepared by another, even in one's own office, can be difficult, time consuming, or even impossible. Streamlining the flow of data through the use of a consistent layering standard means less duplication of effort in producing drawings, more accurate bids, reduced construction time and costs, and fewer construction errors in the field.

2.3 A SIMPLER SMACNA CAD LAYER GUIDELINE

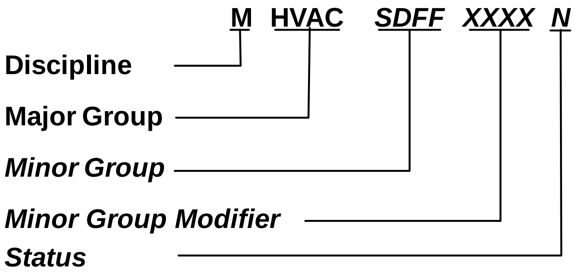
The CAD Layer Guidelines in this current edition have been revised and simplified substantially since they were first released in SMACNA's 1996 edition of the *CADD Symbols and Layering Guidelines*, and with good reason. After careful examination, SMACNA determined that most of the layers variables defined for material types, classification and gages, and special conditions identified in the first edition are more appropriately stored in CAD drawing files as attribute data and do not necessarily require their own separate layers. Using attribute data performs a similar function for character based data, that layers do for visual data. Layers enable CAD users to organize building information into visual reports where layers are selectively turned on and off to produce a drawing displaying specific information. Attribute data enables character based data to be stored in a drawing, typically at the block level as a property, where it can be selectively retrieved for the purpose of generating character based reports summarizing important properties like project cost or existing building conditions.

2.4 BACKGROUND OF THE SMACNA CAD STANDARD

SMACNA's first edition CAD Layer Guidelines defined layer names with a maximum length of eight characters to speed data entry. CAD systems like AutoCAD® were more character based and, typically, CAD users typed in layer names, so the shorter the name the better. Today's CAD systems support layer names up to 255 characters in length with much greater flexibility. This is the environment in which the latest version of the *National CAD Standard* (NCS) layer guidelines was developed by the American Institute of Architects. This standard is a much more legible one using a maximum of 18 characters. In an effort to comply with NCS and the larger AEC community SMACNA has adopted the NCS standard in principle and expanded upon it, providing standard layer names for a wider range of mechanical, fire protection, and plumbing components. Credit should be given to the University of Minnesota whose Department of Facilities Management made substantial contributions to SMACNA's effort to refine its layer standard. Credit should also be given to the Department of Defense's Tri-Services CAD/GIS Center and the role that it has played in standardizing the use of CAD layers.

2.5 LAYER STRUCTURE

Recent CAD software releases have supported much longer layer names making it easier to recognize the contents of a layer from its name alone. While CAD software can support layer names of up to 255 characters, the ultimate limitation is the human interface; CAD users can only comprehend and manipulate layer names that are of a practical length. So rather than use the maximum number of characters in a layer name, SMACNA has adopted the NCS standard for its brevity, clarity, and consistency. SMACNA's layer naming standard uses a minimum of 6 characters up to a maximum of 18 characters. Hyphens are inserted at precise positions to separate layer names into logical and easily readable components as follows:



where each field is defined as follows:

Discipline is a mandatory one-character field describing the discipline under which a layer's content is categorized. SMACNA recommends three disciplines, F for Fire Protection, M for Mechanical, and P for Plumbing, resulting in standard layer names like F-PROT, M-HVAC and P-STRM.

It is important to note explicitly that the purpose of the discipline field is not to identify the author of a layer. Disciplines frequently do work traditionally performed by other disciplines, especially on smaller projects. Using the discipline field to denote layer authorship would introduce inconsistency into layer names, not only across industries, but even with small offices, thus this interpretation is not supported by the SMACNA standard.

SMACNA recognizes that NCS has expanded its own discipline field to include an optional second character where required. SMACNA supports the expansion of this field where it is used to further denote layer content, not authorship.

Major Group is a mandatory four-character field describing building systems. Generally, major groups are associated with a specific discipline; however, it is possible for the responsibility of a major group to be shared by two disciplines resulting in layer names like M-HVAC and P-HVAC. Annotation, *-ANNO-*, is the only major group that is not a building system. It is described separately in section 2.12.

Minor Group is an optional four-character field used to further differentiate major groups, *e.g.* the need to separate supply and return ductwork results in the layer names M-HVAC-SDFF and M-HVAC-RDFF. While the majority of minor groups modify a specific major group, four minor groups may be used to modify virtually all of the major groups:

ELEV:	denotes an elevation view, *e.g.* M-HVAC-ELEV
IDEN:	denotes symbols or text that need to remain on even when text layers are turned off, *e.g.* M-HVAC-IDEN.
PATT:	denotes hatch patterns, *e.g.* M-HVAC-PATT.
RDME:	denotes read-me layer, text not to be plotted, *e.g.* M-HVAC-RDME

Minor Group Modifier is an optional four-character field used to further differentiate minor groups, *e.g.* M-HVAC-DOOR-IDEN denotes labels that identify mechanical access doors.

Status is an optional one character field describing the construction state of a layer's contents:

N	New Work
E	Existing to Remain
D	Existing to Demolish
F	Future Work
T	Temporary Work
M	Items to Be Moved
R	Relocated Items
X	Not in Contract
1-9	Phase Numbers
A	As Built

e.g. M-HVAC-RETN-D denotes a layer containing Mechanical-Heating, Ventilation, and Air Conditioning - Return Ducts - To Be Demolished.

2.6 GUIDELINES FOR LAYER USE

1. Use only the layers that your work requires. Develop a list of standard layers for your practice by selecting layers from the standard lists provided in these guidelines. If you do not find all of the layer names that you need, create your own new major groups along with new minor group and minor group modifier fields. These guidelines are intended to be flexible and to provide a structure from which to define new layers.

2. It is important that each layer name field have exactly the same number of characters that are specified in this standard, *e.g.* the major group field must contain four and exactly four characters. Adhering to a consistent layer standard enables each character position in a layer name to retain the same meaning, making it easier to turn groups of layers on and off with layer name wild cards.

3. Don’t use more layer fields than your work requires. The minimum layer name requires only the mandatory fields, discipline and major group. These are frequently sufficient to describe the contents of a layer.

4. Layer fields are interchangeable and may be combined in an infinite number of ways as long as they describe a system that actually exists, *e.g.* P-CHIM-FLDR denoting floor drains installed in a chimney by a plumbing discipline is not a physically meaningful layer name.

5. To be in compliance with these layer guidelines, do not rename layers that are already defined, *e.g.* M-HVAC-EQPM is in compliance while M-HVAC-EQPT is not.

6. To ensure consistent layer use in your practice, create drawing template files containing standard layers for each type of drawing that you produce. Use script files to add layers to template files. Creating new layers manually can be very error prone and should be avoided. Develop scripts to create layers required for a major group or a set of major groups. Develop versions of these script files, one for new construction with its shorter layer list and another for renovation projects with the longer layer list required to describe construction status, to name but a couple of conditions. Use these scripts in combination to produce template files for the simplest and the most complex projects. Scripts may also be used to add new layers to active projects whose scope has increased.

   Note that the latest CAD software releases now include menus to develop drawing template files using NCS layers, finally offering a solution to the problem of creating drawing template files that are more efficient than writing and running script files.

7. Generally, plan drawings pose the most challenging layer coordination effort, since the work of several disciplines must be integrated. Details and three-dimensional drawings have their own special requirements which are covered in their own separate section.

8. Use hatch patterns sparingly to avoid making drawings too difficult to read. Place hatch patterns on their own separate “PATT” layer to prevent them from interfering with precise drafting where they can clutter a drawing with misleading snap coordinates. Place hatch pattern boundary polygons on a separate layer, usually the nonplot layer, “NPLT”, for all of the same reasons and, especially, to prevent these polygons from being unintentionally edited. It’s much easier to edit hatch patterns and their boundaries together if they can be isolated from the rest of the layers in your drawing set.

9. Revise earlier projects to comply with NCS standards only to the degree that it adds value to your practice. It is often cost effective to convert projects incrementally, rather than all at once. Also, if a project’s layer contents map in a one to one manner with NCS standard layers, then layers may be renamed in the future as required.

2.7 MECHANICAL LAYERS

Brine Systems	M-BRIN	Brine system
	M-BRIN-EQPM	Brine system equipment
	M-BRIN-PIPE	Brine system piping
Chilled Water Systems	M-CWTR	Chilled water system
	M-CWTR-EQPM	Chilled water equipment
	M-CWTR-PIPE	Chilled water piping
Chimneys and Stacks	M-CHIM	Prefabricated chimneys and stacks
Compressed Air Systems	M-CMPA	Compressed air system
	M-CMPA-CEQP	Compressed air equipment
	M-CMPA-CPIP	Compressed air piping
Condenser Water Systems	M-CNDW	Condenser water system
	M-CNDW-EQPM	Condenser water equipment
	M-CNDW-PIPE	Condenser water piping
Controls and Instrumentation Systems	M-CONT	Controls and instrumentation
	M-CONT-THER	Thermostats
	M-CONT-WIRE	Low voltage wiring
Dual Temperature Systems	M-DUAL	Dual temperature system
	M-DUAL-EQPM	Dual temperature equipment
	M-DUAL-PIPE	Dual temperature piping
Dust Collection Systems	M-DUST	Dust collection system
	M-DUST-DUCT	Dust collection ductwork
Dust Collection Systems (continued)	M-DUST-EQPM	Dust collection equipment
Electric Heat Systems	M-ELHT-EQPM	Electric heat equipment
Energy Management Systems	M-ENER	Energy management system
	M-ENER-EQPM	Energy management equipment
	M-ENER-WIRE	Energy management wiring
Energy Recovery Systems	M-RCOV	Energy recovery system
	M-RCOV-EQPM	Energy recovery equipment
	M-RCOV-PIPE	Energy recovery piping
Exhaust Systems	M-EXHS	Exhaust system
	M-EXHS-CDFF	Exhaust ceiling diffusers
	M-EXHS-DUCT	Exhaust system ductwork
	M-EXHS-EQPM	Exhaust system equipment
	M-EXHS-RFEQ	Rooftop exhaust equipment
Fuel Systems	M-FUEL	Fuel system; *e.g.* liquid propane, diesel oil, or natural gas
	M-FUEL-EQPM	Fuel system equipment
	M-FUEL-GGEP	Fuel gas general piping
	M-FUEL-GPRP	Fuel gas process piping
	M-FUEL-OGEP	Fuel oil general piping
	M-FUEL-OPRP	Fuel oil process piping
	M-FUEL-RPIP	Fuel distribution return piping

MECHANICAL LAYERS (continued)

Fuel Systems (continued)	M-FUEL-SPIP	Fuel distribution supply piping
Fume Exhaust Systems	M-FUME	Fume hood exhaust system
	M-FUME-DUCT	Fume hood exhaust ductwork
	M-FUME-EQPM	Fume hood equipment
Hot Water Heating Systems	M-HOTW	Hot water heating system
	M-HOTW-EQPM	Hot water equipment
	M-HOTW-PIPE	Hot water piping
HVAC Systems	M-HVAC	HVAC system
	M-HVAC-CDFF	HVAC ceiling diffusers
	M-HVAC-DOOR	HVAC equipment doors and access doors
	M-HVAC-EQPM	HVAC equipment
	M-HVAC-IDEN	HVAC diffuser tags
	M-HVAC-LSDF	Life safety fire damper
	M-HVAC-ODFF	HVAC other diffusers
	M-HVAC-OTHR	Other ductwork
	M-HVAC-RDFF	Return air diffusers
	M-HVAC-RETN	Return ductwork
	M-HVAC-SDFF	Supply diffusers
	M-HVAC-SUPP	Supply ductwork
Industrial Exhaust Systems	M-INEX	Industrial exhaust systems
	M-INEX-CDFF	Industrial exhaust air ceiling diffusers
	M-INEX-DUCT	Industrial exhaust ductwork
	M-INEX-EQPM	Industrial exhaust equipment
Laboratory Gas Systems	M-LGAS	Laboratory gas system
Laboratory Gas Systems (continued)	M-LGAS-EQPM	Laboratory gas equipment
	M-LGAS-PIPE	Laboratory gas piping
Machine Shop Systems	M-MACH	Machine shop equipment
Medical Gas Systems	M-MDGS	Medical gas system
	M-MDGS-EQPM	Medical gas equipment
	M-MDGS-PIPE	Medical gas piping
Make-up Air Systems	M-MKUP	Make-up air system
	M-MKUP-CDFF	Make-up air ceiling diffusers
	M-MKUP-DUCT	Make-up air duct
	M-MKUP-EQPM	Make-up air equipment
Natural Gas Systems	M-NGAS	Natural gas system
	M-NGAS-EQPM	Natural gas equipment
	M-NGAS-PIPE	Natural gas piping
Process Air Systems	M-CMPA-PEQP	Process air equipment
	M-CMPA-PPIP	Process air piping
Process Systems	M-PROC	Process system
	M-PROC-EQPM	Process equipment
	M-PROC-PIPE	Process piping
Relief Air Systems	M-RAIR	Relief air system
Refrigeration Systems	M-REFG	Refrigeration system
	M-REFG-EQPM	Refrigeration equipment
	M-REFG-PIPE	Refrigeration piping
Smoke Extraction Systems	M-SMOK	Smoke extraction system
	M-SMOK-CDFF	Smoke extraction ceiling diffusers
	M-SMOK-DUCT	Smoke extraction duct
	M-SMOK-EQPM	Smoke extraction equipment

MECHANICAL LAYERS (continuted)

Special Mechanical Systems	M-SPCL	Special system
	M-SPCL-EQPM	Special system equipment
	M-SPCL-PIPE	Special system piping
Test Equipment	M-TEST	Test equipment
Steam Systems	M-STEM	Steam system
	M-STEM-CONP	Steam condensate piping
	M-STEM-EQPM	Steam equipment
	M-STEM-HPIP	High pressure steam piping
	M-STEM-LPIP	Low pressure steam piping
	M-STEM-MPIP	Medium pressure steam piping

2.8 PLUMBING LAYERS

Acid Waste Systems	P-ACID	Acid, alkaline, oil waste systems
	P-ACID-EQPM	Acid, alkaline, oil waste equipment
	P-ACID-PIPE	Acid, alkaline, oil waste piping
	P-ACID-VENT	Acid, alkaline, oil waste vents
Domestic Water Systems	P-DOMW	Domestic hot and cold water system
	P-DOMW-CPIP	Domestic cold water piping
	P-DOMW-EQPM	Domestic hot and cold water equipment
	P-DOMW-HPIP	Domestic hot water piping
	P-DOMW-RISR	Domestic hot and cold water risers
	P-DOMW-RPIP	Domestic hot water recirculation piping
Sanitary Systems	P-SANR	Sanitary system
	P-SANR-EQPM	Sanitary equipment
	P-SANR-FIXT	Sanitary fixtures
	P-SANR-FLDR	Sanitary floor drains
	P-SANR-PIPE	Sanitary piping
	P-SANR-RISR	Sanitary risers
	P-SANR-VENT	Sanitary vent piping
Storm Drainage Systems	P-STRM	Storm drainage system
	P-STRM-PIPE	Storm drainage piping
	P-STRM-RFDR	Storm roof drains
	P-STRM-RISR	Storm drainage risers

2.9 FIRE PROTECTION LAYERS

Fire Protection Systems	F-PROT	Fire protection system
	F-PROT-ALRM	Fire alarm
	F-PROT-EQPM	Fire protection equipment, *e.g.* fire hose, extinguisher cabinets
	F-PROT-SMOK	Smoke detectors/heat sensors
Fire Protection Sprinkler Systems	F-SPRN	Fire protection sprinkler system
	F-SPRN-CLHD	Sprinkler head-ceiling
	F-SPRN-EQPM	Fire sprinkler equipment, *e.g.* diesel fire pumps
	F-SPRN-OTHD	Sprinkler head-other
	F-SPRN-PIPE	Sprinkler piping
	F-SPRN-STAN	Sprinkler system standpipe
Fire Protection Standpipe Systems	F-STAN	Fire protection standpipe system
Fire Suppression Systems	F-AFFF	Aqueous film-forming foam system
	F-AFFF-EQPM	Aqueous film-forming foam equipment
	F-AFFF-PIPE	Aqueous film-forming foam piping
	F-CO2S	CO2 System
	F-CO2S-EQPM	CO2 equipment
	F-CO2S-PIPE	CO2 sprinkler piping
	F-HALN	Halon
	F-HALN-EQPM	Halon equipment
	F-HALN-PIPE	Halon piping
	F-IGAS	Inert gas
	F-IGAS-EQPM	Inert gas equipment
	F-IGAS-PIPE	Inert gas piping

2.10 DRAWING VIEW LAYER LIST

When organizing layers by drawing type, the NCS 2.0 provides for the creation of Drawing View Groups DETL, ELEV, and SECT. This four character field may be used as a major group, a minor group, or as a minor group modifier, *e.g.* it may be used to modify any building system major group, such as: M-HVAC-DETL, etc. To remain in compliance with SCS and NCS 2.0, do not exceed the maximum number of layer name characters defined in section 2.5.

An optional field, ANNN, used exclusively as a modifier to Drawing View Groups, provides a more detailed means of structuring or cataloging drawings. It consists of a four character wide field, where the first character is alphabetic and the last three characters are numeric, *e.g.* A001, B102, etc. To provide for maximum flexibility, the meaning of this layer group is user defined. It is strongly recommended that the precise usage (definition) of these layers, be documented and submitted with each set of drawings where it is used.

Note that the minor group fields used in the examples below, MCUT, MBND, PATT, IDEN, and OTLN may be used to modify any major or minor group.

*-DETL	Detail Drawing View
*-ELEV	Elevation Drawing View
*-SECT	Section Drawing View
*-****-ANNN	Drawing View—Optional Number
*-****-ANNN-MCUT	Drawing View—Optional Number—Material Cut
*-****-ANNN-MBND	Drawing View—Optional Number—Material Beyond Cut
*-****-ANNN-PATT	Drawing View—Optional Number—Textures and Hatch Patterns
*-****-ANNN-IDEN	Drawing View—Optional Number—Component Identification Number
*-****-ANNN-OTLN	Drawing View—Optional Number—Outline of Object Drawn

2.11 THREE DIMENSIONAL DRAWINGS

Three-dimensional drawings provide tremendous design and construction advantages. Since building a model is just like real construction, it helps tremendously if building system components are organized into building system layers. Selectively turning on only the required building system component layers helps you to see what you are doing and it speeds up the whole modeling process. Being able to isolate layers by building system helps to identify interference problems between building system components well before they become expensive construction errors in the field. Both the NCS and SCS layering guidelines support this modeling process very well.

To separate 2D from 3D building system components, the NCS 1.0 recommended appending the modifier "ELEV" to a layer name to denote it as a three-dimensional drawing, *e.g.*

M-HVAC-RDFF	Mechanical—HVAC—Return Air Diffuser (two dimensional)
M-HVAC-RDFF-ELEV	Mechanical-HVAC-Return Air Diffuser—ELEV (three dimensional)

Sorting two dimensional components from three dimensional components by layer is often no longer necessary today, because CAD systems are now more object oriented and integrated. To display a two or three-dimensional view no longer requires layers to be turned on and off. Instead, the orientation of the model view is altered to change its perspective.

Legacy CAD systems can provide challenges when sharing files between disciplines. 3D file sizes can be quite large and contain more information than a file recipient needs; sometimes overwhelming the computational power of existing computer equipment. Planning is required to transmit only the information that is required. The recipient of such files needs to ensure that their hardware and software are sufficient to process the files. Running system compatibility tests is essential before entering into a contractual agreement and commencing with work.

2.12 ANNOTATION LAYERS

Annotation is the only major group that is not a building system. Since annotation is required to describe building system components in several distinct ways, annotation is assigned its own set of unique layers. This is also useful, because annotation can interfere with precise drafting, offering a multitude of erroneous snap coordinates. Generally, drawings can be edited faster if annotation is placed on separate layers where it can be turned on and off as needed. Currently, the NCS 2.0 annotation layer guidelines state:

> *Annotation consists of text, dimensions, notes, sheet borders, detail references and other elements on CAD drawings that do not represent physical aspects of a building. Use of the Major Group ANNO allows all annotation to be placed in a defined group of layers.*
>
> *The layer names shown below encompass the complete list of prescribed Minor Group field codes for annotation. These Minor Groups may be used to modify any Major or Minor Group.*

*-ANNO-DIMS	Dimensions
*-ANNO-KEYN	Keynotes
*-****-IDEN	Identification tags
*-ANNO-LABL	Labels
*-ANNO-LEGN	Legends and schedules
*-ANNO-MARK	Elevation, section, detail, and break marks & leaders
*-ANNO-MATC	Match lines
*-ANNO-NOTE	Notes
*-ANNO-NPLT	Non-plotting graphic information
*-****-RDME	Read-me layer (not plotted)
*-ANNO-REDL	Redline
*-ANNO-REFR	Reference layer to external data files
*-ANNO-REVC	Revision clouds
*-ANNO-REVS	Revisions
*-ANNO-REVT	Review text and triangle
*-ANNO-SCHD	Schedules
*-ANNO-SYMB	Symbols
*-ANNO-TABL	Data tables
*-ANNO-TEXT	Text
*-ANNO-TITL	Drawing or detail titles
*-ANNO-TTLB	Border and Title block

Above, * denotes the discipline responsible for the layer.

Annotation can be applied to a model via at least two techniques.

By Reference File and Layer

To facilitate sharing of the base model among disciplines by encouraging concurrent editing, the annotation for each drawing can be stored in its own separate drawing file. For example, to generate a plotted sheet of a plan drawing, at lease three separate drawing files are combined:

- A base architecture plan drawing file;
- A discipline overlay drawing file including both building system and annotation layers; and
- A sheet title block overlay drawing file that frames the base architecture and discipline overlay files.

By Layer Only

Separating annotation into reference files can be cumbersome for smaller projects. Sometimes it is more efficient to combine the annotation for several different drawings into a single drawing file. Using scripts or saved sheet layouts, sets of layers can be turned on and off automatically to display several different drawings complete with their own annotation, without the additional steps of opening and closing files. To separate one drawing's set of annotation from another, a separate set of annotation layers is required for each. Each set of drawing annotation can be uniquely identified by appending an annotation minor group as modifier to a major group or a minor group, *e.g.*

M-HVAC-TEXT	denotes the text annotation for the HVAC drawing;

M-HVAC-EQPM-TEXT	denotes the text annotation for the HVAC equipment drawing.

Note that using annotation groups in this manner precludes the use of the second minor modifier field for any other purpose for a given layer, e.g. you could not create a layer for text annotation describing floor mounted HVAC equipment. The layer name "M-HVAC-EQPM-FLOR-TEXT" would exceed the length of the layer name permitted by NCS.

2.13 SAMPLE DRAWING ORGANIZATION

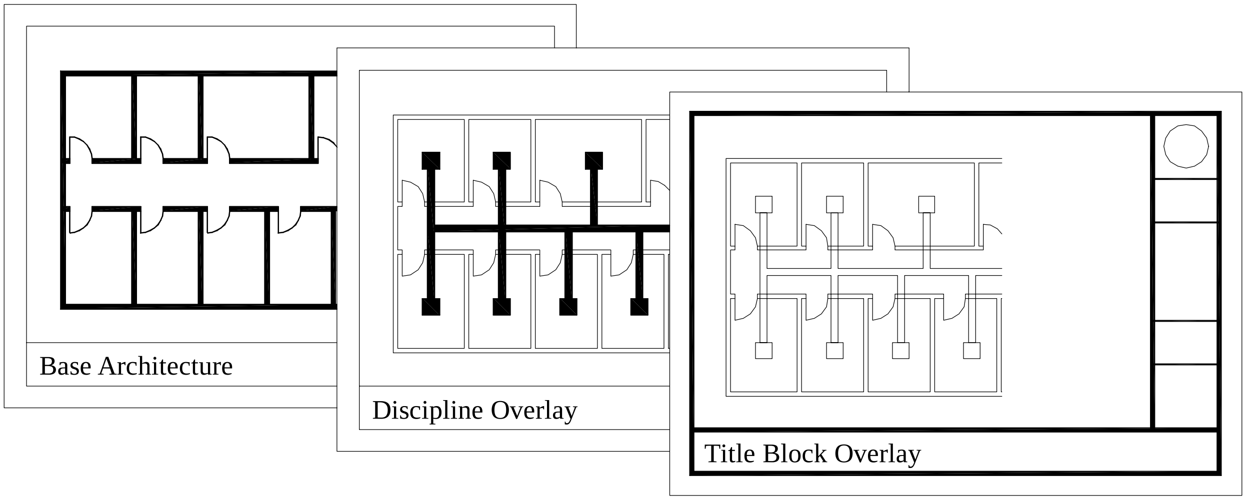
A small new construction project might contain only the following layers:

2.13.1 Base Architecture File

A-WALL	Architecture—Walls
A-DOOR	Architecture—Door
A-FLOR-CASE	Architecture—Floor—Casework
A-FLOR-EVTR	Architecture—Floor—Elevators
A-FLOR-STRS	Architecture—Floor—Stairs
A-FLOR-PFIX	Architecture—Floor—Plumbing Fixtures
S-COLS	Structure—Columns
S-GRID	Column Grid
I-WALL	Interior—Walls
I-DOOR	Interior—Doors

2.13.2 Mechanical Discipline File

M-HVAC-CDFF	HVAC ceiling diffusers
M-HVAC-DOOR	HVAC equipment doors
M-HVAC-EQPM	HVAC equipment
M-HVAC-IDEN	HVAC diffuser tags
M-HVAC-OTHR	Other ductwork
M-HVAC-RETN	Return ductwork
M-HVAC-SUPP	Supply ductwork
M-ANNO-DIMS	Dimensions
M-ANNO-KEYN	Keynotes
M-ANNO-LEGN	Legends and schedules
M-ANNO-NOTE	Notes
M-ANNO-NPLT	Nonplotting Construction lines
M-ANNO-REDL	Redline



M-ANNO-REVS	Revisions
M-ANNO-SYMB	Symbols
M-ANNO-TEXT	Text

2.13.3 Title Block File

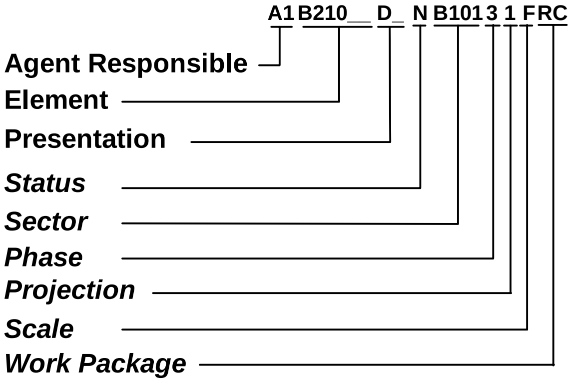
M-ANNO-TTLB	Border and Title block

A renovation project of any size requires a longer list of layers denoting construction status. For each of the building system component layers listed above, three layers are required denoting construction status, *e.g.*

M-HVAC-RDFF-E	Return air diffusers - Existing to Remain
M-HVAC-RDFF-D	Return air diffusers - Existing to Demolish
M-HVAC-RDFF-N	Return air diffusers—New Work

2.14 ANNOTATION LAYERS AND INTERNATIONAL STANDARDS

The NCS *CAD Layer Guidelines* are a standard that works well within the United States, but differences do exist between this national standard and the International Standards Organization layer standard developed and adopted by 14 countries including the United States. Unfortunately, the manner in which the NCS standard defines annotation is not in compliance with the ISO. The full ISO layer standard structure is as follows:



The first three fields are mandatory and the remaining six fields are optional. The first three fields are the most important for this discussion. The ISO's Agent Responsible field corresponds to the NCS's Discipline field. The ISO's Element field corresponds to the NCS's Major Group field. The third ISO field, Presentation, the annotation field, is the source of the problem. The ISO has chosen to associate annotation with each building system while NCS has defined annotation as a major group. These standards are in direct conflict and pose difficulty for any United States firm trying to comply with the NCS standard while doing work overseas.

Recently, NCS has readopted the use of an additional minor group modifier, enabling the annotation fields to be appended to a layer root name defined by its discipline and major group fields. For example, annotation layers for HVAC plans can result in layers like:

M-HOTW-EQPM-TEXT,
M-HOTW-PIPE-TEXT,
M-HVAC-EQPM-TEXT, etc.

By employing this method, NCS standard layers can map on a one-to-one basis with ISO standard layers, thus enabling compliance with both NCS and ISO standards.

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CHAPTER 3

ABBREVIATIONS

ABBREVIATIONS / DESCRIPTIONS

The following list of abbreviations is commonly used to describe the referenced item. For a more extensive listing of abbreviations, including those for disciplines not normally associated with HVAC, see Section UDS-05 Terms and Abbreviations of the National CAD Standard. The abbreviations and descriptions are as follows:

3.1 A

AAD	Automatic air damper
AAV	Automatic air vent
ABS	Absolute
ABSORB	Absorption
ACCU	Air Cooled Condensing Unit
ACID RES	Acid resistant
ACID RES CI	Acid resistant cast iron
ACID RES P	Acid resistant pipe
ACID RES V	Acid resistant vent
ACID RES W	Acid resistant waste
ACCUM	Accumulator
ACP	Automatic Control Panel
ACS	Automatic Control System
A/C	Air Conditioning
ACU	Air Conditioning Unit
ACV	Automatic Control Valve
AC	Alternating Current
AD	Access Door, Area Drain
ADA	American Disabilities Act
ADD	Addition
ADJ	Adjustable
ADP	Apparatus Dew Point
AE	Anesthesia Evacuation
AFF	Above Finished Floor
AFMS	Air Flow Measuring Station
AHP	Air Horsepower
AHU	Air Handling Unit
ALT	Altitude, Alternate
AMB	Ambient
AMP	Ampere (Amp, Amps)
ANSI	American National Standards Institute
AP, ACS PNL	Access Panel
APD	Air Pressure Drop
APPROX	Approximat(e), (ely)
AR	Air Relief, As Required
ARCH	Architect
ARV	Air Relief Valve
AS	Air Separator
ASU	Air Supply Unit
ASV	Angle Stop Valve
ATM	Atmosphere
AV	Acid Vent, Air Vent
AVG	Average
AW	Acid Waste
AWG	American Wire Gauge
AX FL	Axial Flow

3.2 B

B&S	Brown & Sharp Wire Gauge, Bell & Spigot
BAL	Balance
BAPR	Barometric Pressure
BARO	Barometer
BBD	Boiler Blow Down
BBR	Baseboard radiator
BCV	Butterfly Check Valve
BD	Butterfly Damper
BDD	Backdraft Damper
BFP	Backflow Preventer
BFV	Butterfly Valve
BFW	Boiler Feed Water
BFWP	Boiler Feed Water Pump
BHP	Brake Horsepower
BLDG	Building
BLO	Blower
BLR	Boiler
BLR HP	Boiler Horsepower
BOM	Bill of Material
BP	Boiling Point
BSP	Black Steel Pipe
BT	Bath Tub
BOT	Bottom
BTU	British Thermal Unit
BV	Ball Valve
BYP	By Pass

3.3 C

CA	Compressed Air
CAV	Constant Air Volume

C/C, CC	Cooling Coil
CCW	Counter Clockwise
CD	Condensate Drain, Ceiling Diffuser
CDW	Chilled Drinking Water
CDWR	Chilled Drinking Water Return
CDWS	Chilled Drinking Water Supply
CFM	Cubic Feet per Minute
CFOI	Contractor Furnished/Owner Installed
CFS	Cubic Feet Per Second
CH	Chiller
CHCF	Chilled Water Chemical Feed
CHKV	Check Valve
CHWM	Chilled Water Make-up
CHWP	Chilled Water Pump
CHWPP	Chilled Water Primary Pump
CHWR	Chilled Water Return
CHWRP	Chilled Water Recirculating Pump
CHWS	Chilled Water Supply
CHWSP	Chilled Water Secondary Pump
CI	Cast Iron
CIP	Cast Iron Pipe
CISP	Cast Iron Soil Pipe
CKT	Circuit
CLG	Ceiling
CLG DIFF	Ceiling Diffuser
CLG GRL	Ceiling Grille
CLG HT	Ceiling Height
CLG REG	Ceiling Register
CW	Clockwise
CO	Clean Out
CO2	Carbon Dioxide
COEFF	Coefficient
COL	Column
COMP	Compressor
CONC	Concrete
COND	Condens(er), (ing), (ation), Condition
CONST	Construction
CONT	Continuou(s), (e)
CONV	Convector
COP	Coefficient of Performance (Heating), Copper
COTG	Cleanout to Grade
CCP	Cooling Coil Pump
CP	Condensate Pump
CPD	Condensate Pump Discharge
CPLG	Coupling
CR	Control Relay
CRP	Condensate Return Pump
CSG	Casing
CT	Cooling Tower
CTR	Cooling Tower Return
CTS	Cooling Tower Supply
CU	Condensing Unit
CV	Control Valve
CU FT	Cubic Feet
CU IN	Cubic Inches
CU YD	Cubic Yard
CUH	Cabinet Unit Heater
CW	Cold Water
CWCF	Condenser Water Chemical Feed
CWP	Condenser Water Pump
CWR	Condenser Water Return
CWS	Condenser Water Supply

3.4 D

DA	Dental Air
DAP	Duct Access Panel
dB	Decibel(s)
DB	Dry Bulb Temperature
DC	Direct Current
DCI	Duct Covering Insulation
DDC	Direct Digital Control
DEG	Degree
DENS	Density
DEPT	Department
DF	Drinking Fountain
DH	Duct Heater
DIW	De-ionized Water
DIA	Diameter
DIP	Ductile Iron Pipe
DISCH	Discharge
DLI	Duct Liner Insulation
DMPR	Damper
DP	Dewpoint
DPS	Differential Pressure Sensor
DPT	Dew Point Temperature
DR	Drain
DS	Downspout
DST	Daylight Savings Time

DT	Delta Temperature
DUC	Door Undercut
DW	Distilled Water
DWG	Drawing
DWV	Drain, Waste, and Vent

3.5 E

EAG, EXH GR	Exhaust Air Grille
EAR	Exhaust Air Register
EAT	Entering Air Temperature
EBB	Electric Base Board
EC	Electrical Contractor, Edge of Curb
ECC RDCR	Eccentric Reducer
ECON	Economizer
ECU	Evaporative Cooling Unit
ECWR	Equipment Cooling Water Return
ECWS	Equipment Cooling Water Supply
EDBT	Entering Dry Bulb Temperature
EDH	Electric Duct Heater
EDR	Equivalent Direct Radiation
EER	Energy Efficiency Ratio
EF, EXH FN	Exhaust Fan
EFF	Efficiency
EHP	Electric Heating Panel
EL	Elevation
ELEC	Electric
ELEV	Elevator
EMER	Emergency
EMER SHR	Emergency Shower
EMF	Electromotive Force
EM	Electromagnetic
ENCL	Enclosure
ENG	English Units
ENT	Entering
EOM	End of Main
EOV	Electrically Operated Valve
EPRF	Explosion Proof
EQIV FT	Equivalent Feet
EQIV IN	Equivalent Inches
EQUIP	Equipment
ERD	Existing Roof Drain
ESC	Escutcheon, Escape
ESP	External Static Pressure
EST	Eastern Standard Time
ET	Expansion Tank
EUH, EH	Electric (Unit) Heater
EVAP	Evaporat(e), (ing), (ed), (or)
EWS	Eye Wash Station
EWC	Electric Water Cooler
EWBT	Entering Wet Bulb Temperature
EWH	Electric Water Heater
EWT	Entering Water Temperature
EXCH	Exchanger
EXH	Exhaust
EXH A	Exhaust Air
EXH DT	Exhaust Duct
EXH FN	Exhaust Fan
EXH GR	Exhaust Air Grille
EXH HD	Exhaust Hood
EXHV	Exhaust Vent
EXIST	Existing
EXP	Expansion
EXT	Exterior

3.6 F

F	Fahrenheit
F&B	Face and By-pass
F&T	Float and Thermostatic Trap
FA	Face Area
FAG	Forced Air Gas (Furnace)
FAI	Flexible Air Intake
FC	Flexible Connection
FCO	Floor Cleanout
FCU	Fan Coil Unit
FD	Floor Drain, Fire Damper
FDC	Fire Department Connection, Flexible Duct Connection
FF	Final Filters
FFA	From Floor Above
FFB	From Floor Below
FH	Fire Hose
FHC	Fire Hose Cabinet
FIN	Finish
FIXT	Fixture
FLEX	Flexible
FLR	Floor
FL SW	Flow Switch
FLR REG	Floor Register
FLR SK	Floor Sink

FLTR	Filter
FO	Fuel Oil
FOP	Fuel Oil Pump
FOR	Fuel Oil Return
FOS	Fuel Oil Supply
FOV	Fuel Oil Vent
FP	Fire Protection
FPC	Fire Protection Contractor
FPCV	Fan Powered Constant Volume
FPT	Fan Powered Terminal
FTLB	Foot Pound
FPM	Feet per Minute
FPS	Feet per Second
FPVAV	Fan Powered Variable Air Volume
FRP	Fiberglass Reinforced Plastic
FSD	Fire Smoke Damper
FSS	Flow Sensing Switch
FSTAT	Freezestat
FTG	Footing
FURN	Furnace, Furnish, Furniture
FUS LINK	Fusible Link
FWR	Filter Water Return
FWS	Filter Water Supply
FV	Face Velocity

3.7 G

G	Natural Gas
G LN	Gas Line
GA	Gage
GAL	Gallon
GALV	Galvanized
GC	General Contractor
GPD	Gallon per Day
GPH	Gallon per Hour
GPM	Gallon per Minute
GPS	Gallon per Second
GR	Glycol Return
GS	Glycol Supply
GT	Grease Trap
GTD	Greatest Temperature Difference

3.8 H

HB	Hose Bib
HC	Hose Closet
HCP	Heating Coil Pump (Hot Water)
HD	Head
HE	Helium
HEPA	High Efficiency Particulate Air (Filter)
HEX	Heat Exchanger
HG	Heat Gain or Mercury
HO	Hub Outlet
HOA	Hand, Off, Auto Station
HORIZ	Horizontal
HOSP	Hospital
HP	Horsepower, Heat Pump
HPB	High Pressure Boiler
HPDT	High Pressure Drip Trap
HPR	High Pressure Condensate Return
HPS	High Pressure Steam
HPT	High Pressure Trap
HR	Hour
HS	Hand Sink
HSTAT	Humidistat
HT	Height
HTHW	High Temperature Hot Water
HTR	Heater
HVAC	Heating, Ventilating, and Air Conditioning
HVD	High Velocity Diffuser
HVT	High Velocity Terminal
HW	Hot Water
HWB	Hot Water Boiler
HWC	Hot Water Coil
HWCP	Hot Water Circulating Pump
HWP	Hot Water Pump
HWR	Hot Water Return
HWS	Hot Water Supply
HWT	Hot Water Tank
HWCF	Heating Water Chemical Feed
HTWR	Heating Water Return
HTWS	Heating Water Supply
HZ	Frequency

3.9 I

IAQ	Indoor Air Quality
ID	Inside Diameter
IF	Intake Fan
IHP	Indicated Horsepower
IN WC	Inches, Water Column
INCIN	Incinerator
INCL	Include
INSTR	Instrument
INSUL	Insulat(e), (ed), (ion)
INT	Interior
INV	Invert
I/O	Input/Output
IP	Iron Pipe
IPS	International Pipe Standard
IPT	Iron Pipe Threaded
IWH	Instantaneous Water Heater

3.10 J

JS	Janitor’s Sink
JT	Joint

3.11 K

K	Thermal Conductivity, Kelvin
KEC	Kitchen Equipment Contractor
KIP	Thousand Pounds
KW	Kilowatt
KWH	Kilowatt Hour

3.12 L

LA	Laboratory Air
LAB	Laboratory
LAD	Laminar Air Diffuser
LAF	Laminar Air Flow
LAP	Low Ambient Protection
LAT	Leaving Air Temperature
LATR	Lateral
LAV	Lavatory
LB	Pound
LCD	Linear Ceiling Diffuser
LD	Linear Diffuser
LDBT	Leaving Dry Bulb Temperature
LEN	Length
LF	Linear Feet
LFD	Laminar Flow Diffuser
LG	Liquid Gas
LH	Latent Heat
LHG	Latent Heat Gain
LHR	Latent Heat Ratio
LIQ	Liquid
LMTD	Least Mean Temperature Difference
LN	Liquid Nitrogen
LNG	Liquid Natural Gas
LO	Lubricating Oil
LOC	Location
LOG	Logarithm
LOP	Lubricating Oil Pump
LOV	Lubricating Oil Vent
LOX	Liquid Oxygen
LP	Low Pressure
LPG	Liquified Petroleum Gas
LPAS	Low Pressure Alarm Switch
LPB	Low Pressure Boiler
LPCR	Low Pressure Condensate Return
LPDT	Lower Pressure Drip Trap
LPL	Lightproof Louver
LPR	Low Pressure Return
LPS	Low Pressure Steam
LPV	Light Proof Vent
LTD	Least Temperature Difference
LTHW	Low Temperature Hot Water
LV	Laboratory Vacuum
LVR	Louver
LWBT	Leaving Wet Bulb Temperature
LWCO	Low Water Cut Off
LWT	Leaving Water Temperature

3.13 M

MA	Medical Air, Mixed Air
MACH	Mach Number
MAT	Mixed Air Temperature
MAU, MAHU	Make Up Air Handling Unit
MAV	Manual Air Vent
MAX	Maximum
MB	Mop Basin, Mixing Box
MBH	BTU/Hr x 1,000,000

MC	Mechanical Contractor
MD	Manual Damper
MECH	Mechanical
MED VAC	Medium Vacuum
MET	Mean Effective Temperature
MFR	Mass Flow Rate
MH	Man Hole
MIN	Minimum
MISC	Miscellaneous
MOD	Motor Operated Damper
MOV	Motor Operated Valve
MP	Medium Pressure
MPG	Medium Pressure Gas
MPH	Miles Per Hour
MPR	Medium Pressure Condensate (Return)
MPS	Medium Pressure Steam
MPT	Male Pipe Thread
MTD	Mounted, Mean Temperature Difference
MTHW	Medium Temperature Hot Water
MTL	Metal
MVD	Manual Volume Damper
MZ	Multizone

3.14 N

N	Nitrogen
NA	Not Applicable
NC	Noise Criteria, Normally Closed
NIC	Not In Contract
NO	Nitrous Oxide, Normally Open
NO.	Number
NR	Noise Reduction
NRC	Noise Reduction Coefficient
NTS	Not To Scale

3.15 O

O	Oxygen
OA	Outside Air
OAD	Outside Air Damper
OAG	Outside Air Grille
OAI	Outside Air Intake
OAT	Outside Air Temperature
OBD	Opposed Blade Damper
OD	Outside Diameter
OF/CI	Owner Furnished/Contractor Installed
OFD	Overflow Drain
OF/OI	Owner Furnished/Owner Installed
OPNG	Opening
OSD	Open Sight Drain
OSL	Oil Seal
OSP	Operating Steam Pressure
OS&Y	Open Screw & Yoke
OUT	Outlet
OZ	Ounce

3.16 P

P	Pump
PA	Pipe Anchor
PCC	Precool Coil
PCD	Polyvinyl Coated Duct
PCT	Percent
PCWR	Panel Chilled Water Return
PCWS	Panel Chilled Water Supply
PD	Pressure Drop/Difference
PDISCH	Pump Discharge
PE	Pneumatic Electric
PETRO	Petroleum
PF	Pre-Filter
PH	Phase (electric)
PHC	Preheat Coil
PHWR	Perimeter Heating Hot Water Return
PHWS	Perimeter Heating Hot Water Supply
PIV	Post Indicator Valve
PLMB	Plumbing
PLT	Plaster Trap
PMPSCT	Pump Suction
POC	Point of Connection
PPM	Parts per Million
PR	Pumped Return
PRE	Power Roof Exhaust
PREFAB	Pre-Fabricated
PRES	Pressure
PRESS SW	Pressure Switch
PRI	Primary
PRS	Pressure Reducing Station
PRV	Pressure Reducing Valve, Power Roof Ventilator

PSF	Pounds per Square Foot
PSI	Pounds per Square Inch
PSIA	Pounds Per Square Inch, Absolute
PSIG	Pounds per Square Inch Gage
PSL	Pipe Sleeve
PT	Pneumatic Tube
PTAC	Packaged Terminal Air Conditioner
PTS	Pneumatic Tube Station
PVC	Polyvinyl Chloride

3.17 Q

QT	Quart
QTY	Quantity

3.18 R

R	Thermal Resistance, Rankine
RFGT	Refrigerant
R12	Refrigerant 12
R22	Refrigerant 22
RA	Return Air
RAD	Radiat(e), (or), (ion)
RAF, RA FAN	Return Air Fan
RA GR	Return Air Grille
RAC	Room Air Conditioner
RAD	Return Air Duct
RAT	Return Air Temperature
RCP	Reinforced Concrete Pipe
RD	Roof Drain
REC	Receiver
RECIRC	Recirculat(e), (or), (ing)
RDC	Reducer
REF	Refrigerator
REFR	Refrigeration
REG	Register
RES	Resistance
RFGT	Refrigerant
RAG	Return Air Grille
RH	Relative Humidity
RHC	Reheat Coil
RHG	Refrigerant Hot Gas
RHV	Reheat Valve
RL	Refrigerant Liquid
RLL	Refrigerant Liquid Line
RM	Room
ROW	Reverse Osmosis Water
RP	Radiant Panel
RPM	Revolutions per Minute
RPS	Revolutions per Second
RS	Refrigerant Section
RSC	Rotary Screw Compressor
RSL	Refrigerant Suction Line
RTU	Roof Top Unit
REV	Revolutions, Revision, and Reverse
RV	Relief Valve

3.19 S

SA	Supply Air
SAF	Supply Air Fan
SAN	Sanitary
SAT	Saturated
SB	Sitz Bath
SCC	Steam Condensate Cooler
SCFM	Standard Cubic Feet per Minute
SCFS	Standard Cubic Feet per Second
SCW	Soft Cold Water (Domestic)
SD	Supply Diffuser
SDMPR	Smoke Damper
SEC	Second(s)
SECT	Section
SF	Safety Factor
SAG	Supply Grille
SG	Steam Gage, Specific Gravity
SP GR	Specific Gravity
SH	Sensible Heat
SHG	Sensible Heat Gain
SHP	Shaft Horsepower
SHR	Sensible Heat Ratio
SHR HD	Shower Head
SHR DR	Shower Drain
SHT	Sheet
SHW	Soft Hot Water (Domestic)
SVOL	Secondary Hot Water Return
SHWS	Secondary Hot Water Supply
SJ	Slip Joint
SK	Sink
SL	Sea Level
SLVT	Solvent
SMK	Smoke

SMP	Sump Pump
SOLV	Solenoid Valve
SOV	Shut Off Valve
SP	Sump Pit
SR	Steam Return
SP	Static Pressure
SPEC	Specifications
SPG	Special Gas
SPHT	Specific Heat
SVOL	Specific Volume
SQ	Square
SV	Safety Valve
SRV	Safety Relief Valve
SS	Service Sink, Sanitary Sewer, Standing Seam (Roof), Steam Supply, Storm Sewer, Stainless Steel
SSF	Saybolt Seconds Furol
SSP	Stainless Steel Pipe
SSU	Saybolt Seconds Universal
ST GEN	Steam Generator
STC	Sound Transmission Class
STD	Standard
STM	Steam, Storm
STN	Strainer
STRUCT	Structur(e), (al)
SU	Shower Unit
STN	Strainer
STP	Standard Temperature and Pressure
STWP	Steam Working Pressure
SUCT	Suction
SUH	Suspended Unit Heater
SUPP	Supply
SUTK	Sump Tank
SV	Steam Vent

3.20 T

T	Time
T&P VALVE	Temperature and Pressure Valve
T/S	Tub/Shower
TAB	Tabulat(e), (ion), Test Adjust & Balance
TAG	Transfer Air Grille
TB	Terminal Box
TC	Thermocouple
TCP	Temperature Control Panel
TCV	Temperature Control Valve
TD	Temperature Difference
TDH	Total Dynamic Head
TDV	Triple Duty Valve
TE	Temperature Entering
TEMP	Temperature
TFA	To Floor Above
TFB	To Floor Below
TG	Transfer Grille
THK(NS)	Thick(ness)
TL	Temperature Leaving
TONS	Tons of Refrigeration
TSTAT	Thermostat
TWR	Treated Water Return
TWS	Treated Water Supply
TYP	Typical

3.21 U

U	Heat Transfer Coefficient
UC	Under Cut
UH	Unit Heater
UNO	Unless Noted Otherwise
UR	Urinal
UV	Unit Ventilator

3.22 V

V	Vent
VA	Volt Ampere
VAC	Vacuum
VAL	Valve
VAR	Variable
VAV	Variable Air Volume
VB	Vacuum Breaker
VC	Vacuum Cleaning
VD	Vacuum Damper (Manual)
VEL	Velocity
VENT	Ventilator
VERT	Vertical
VISC	Viscosity
VOL	Volume
VP	Pressure, Dynamic (Velocity)
VPD	Vacuum Pump Discharge (Heating)

VSC	Variable Speed Controller
VT	Vitrified Tile
VTR	Vent Through the Roof
VUH	Vertical Unit Heater
VV	Vacuum Vent
VVT	Variable Volume Terminal

3.23 W

W	Waste
W/	With
W/O	Without
WBT	Wet Bulb Temperature
WC	Water Closet
WCHR	Water Chiller
WCL WL MTD	Water Cooler, Wall Mounted
WCLD	Water Cooled
WCLR	Water Cooler
WCO	Wall Clean Out
WF	Wash Fountain
WH	Wall Hydrant
WHA	Water Hammer Arrestor
WM	Water Meter
WSP	Working Steam Pressure
WT	Weight, Watertight
WTR	Water
WV	Waste Vent

3.24 Y

YCO	Yard Cleanout
YD	Yard
YR	Year

3.25 Z

ZN	Zone

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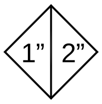
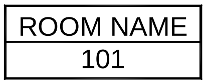
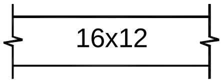
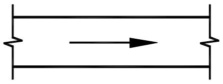
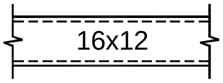
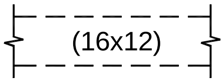
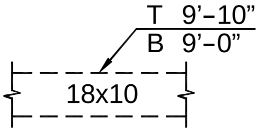
CHAPTER 4

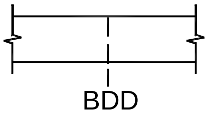
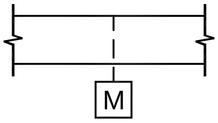
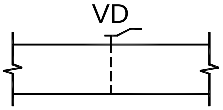
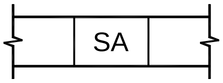
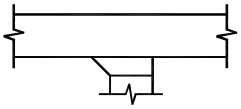
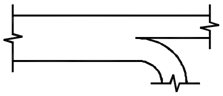
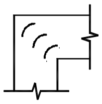
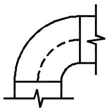
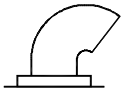
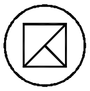
DUCT SYMBOLS

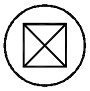
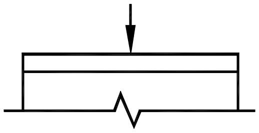
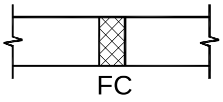
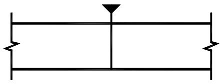
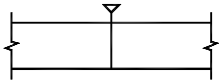
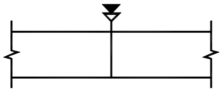
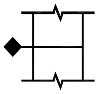
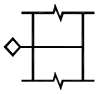
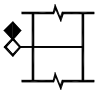
FILE NAME	SYMBOL	DESCRIPTION
DS001	FT	Top of duct fitting is flat
DS002	FB	Bottom of duct fitting is flat
DS003	TD 6” ⟶	Top of duct fitting down 6"
DS004	TU 6” ⟶	Top of duct fitting up 6"
DS005	BD 6” ⟶	Bottom of duct fitting down 6"
DS006	BU 6” ⟶	Bottom of duct fitting up 6"
DS007	RISE 6” ⟶	Ogee offset rising 6"
DS008	DROP 6” ⟶	Ogee offset dropping 6"
DS009		Note tag
DS010		Revision tag

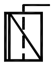
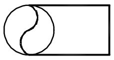
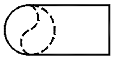
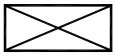
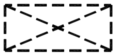
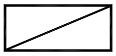
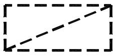
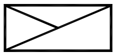
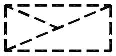
NOTE: For a more extensive library of symbols, including those for other disciplines, see Section UDS-06 Symbols in the National CAD Standard.

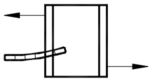
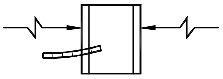
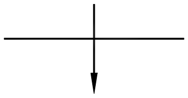
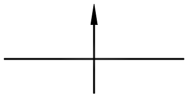
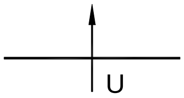
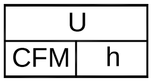
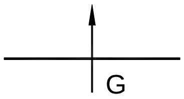
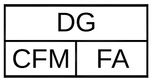
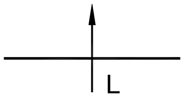
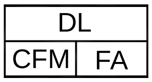
FILE NAME	SYMBOL	DESCRIPTION
DS011		Static pressure tag
DS012		Static pressure change tag
DS013		Room identifier with room name and number
DS014	SP	Static pressure
DS015	FC	Flexible unit connection
DS016	H	End of duct run with head
DS017		Thermostat (electric)
DS018		Humidistat (electric)
DS019		Static pressure sensor
DS020		Smoke detector

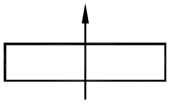
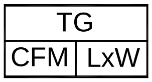
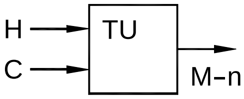
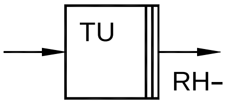
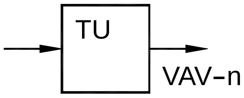
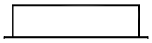
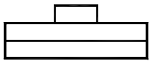
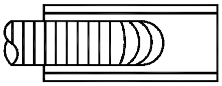
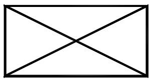
FILE NAME	SYMBOL	DESCRIPTION
DS021		Heat detector
DS022		Flow switch
DS023		Pressure switch
DS024		Duct thermostat
DS025		Duct humidistat
DS026		Sheet metal duct (1st figure, side shown; 2nd figure, other side)
DS027		Direction of flow
DS028		Internally insulated sheet metal duct
DS029		Hidden sheet metal duct
DS030		Duct elevation tag

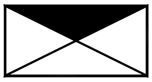
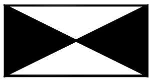
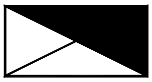
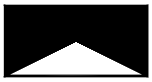
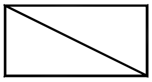
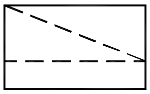
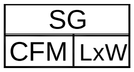
FILE NAME	SYMBOL	DESCRIPTION
DS031		Access door or access panel (AP) in ductwork
DS032		Back draft damper
DS033		Motorized damper
DS034		Volume damper
DS035		Sound attenuator
DS036		Standard branch for supply & return (no splitter)
DS037		Wye junction
DS038		Turning vanes (rectangular)
DS039		Turning vanes (rectangular), smooth radius
DS040		Gooseneck hood (cowl)
DS041		Power or gravity roof ventilator - exhaust (ERV)

FILE NAME	SYMBOL	DESCRIPTION
DS042		Power or gravity roof ventilator (SRV)
DS043		Power or gravity roof ventilator - louvered
DS044		Louvers & screen
DS045		Flex connection
DS046		Fire damper (vertical)
DS047		Smoke damper (vertical)
DS048		Smoke damper and fire damper (vertical)
DS049		Fire damper (horizontal)
DS050		Smoke damper (horizontal)
DS051		Smoke damper and fire damper (horizontal)
DS052		Spin-in without volume damper

FILE NAME	SYMBOL	DESCRIPTION
DS053		Spin-in with volume damper
DS054		Flex duct
DS055		Round elbow up
DS056		Round elbow down
DS057		Supply duct section up
DS058		Supply duct section down
DS059		Return duct section up
DS060		Return duct section down
DS061		Exhaust duct section up
DS062		Exhaust duct section down

FILE NAME	SYMBOL	DESCRIPTION
DS063		Light troffer outlet (supply)
DS064		Light troffer inlet (return)
DS065		Side wall supply grille
DS066		Side wall return grille
DS067		Undercut door
DS068		Undercut door tag (h = clearance)
DS069		Door grille
DS070		Door grille tag
DS071		Door louver
DS072		Door louver tag

FILE NAME	SYMBOL	DESCRIPTION
DS073		Transfer grille or louver
DS074		Transfer grille or louver tag L = Length, W = Width 1st dimension is dimension seen
DS075		Terminal unit, mixing, n = number
DS076		Terminal unit, reheat, n = number
DS077		Terminal unit, variable volume, n = number
DS078		Side wall register
DS079		Side wall diffuser
DS080		Linear slot diffuser
DS081		Combination diffuser and light fixture
DS082		Four-way supply diffuser

FILE NAME	SYMBOL	DESCRIPTION
DS083		Three-way supply diffuser
DS084		Two-way supply diffuser
DS085		Two-way corner supply diffuser
DS086		One-way supply diffuser
DS087		Return air grille
DS088		Return air grille with sound boot
DS089		Typical supply grille (SG), supply diffuser (SD), or supply register (SR) tag. L = Length, W = Width

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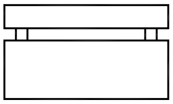
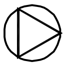
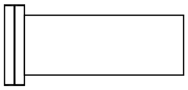
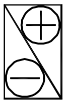
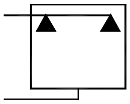
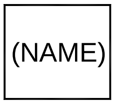
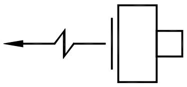
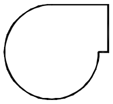
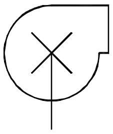
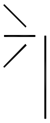
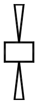
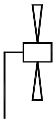
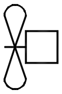
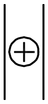
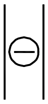
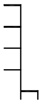
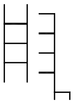
CHAPTER 5

EQUIPMENT SYMBOLS

FILE NAME	SYMBOL	DESCRIPTION
ES001		Chiller
ES002		Pump
ES003		Converter or heat exchanger shell and tube
ES004		Plate heat exchanger
ES005		Cooling tower
ES006		Boiler, air handling unit, water source heat pump (WSHP), etc.
ES007		Unit heater (see Chapter 4 Duct Symbols for other terminal units)
ES008		Centrifugal fan

NOTE: For a more extensive library of symbols, including those for other disciplines, see Section UDS-06 Symbols in the National CAD Standard.

FILE NAME	SYMBOL	DESCRIPTION
ES009		Centrifugal fan with variable inlet vanes
ES010		Duct humidifier
ES011		Vane axial fan
ES012		Vane axial fan, variable pitch
ES013		Propeller fan
ES014		Filter
ES015		Heating coil
ES016		Cooling coil

FILE NAME	SYMBOL	DESCRIPTION
ES017		Electric duct heating coil
ES018		Air flow element
ES019		Air flow station
ES020		Parallel blade damper
ES021		Opposed blade damper

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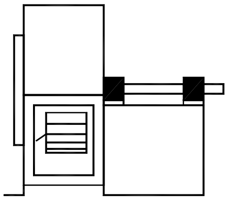
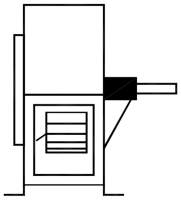
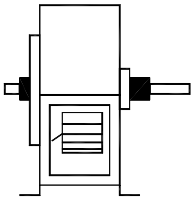
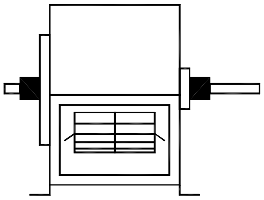
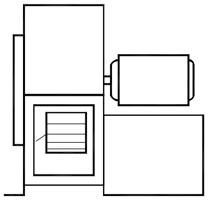
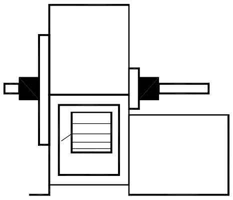
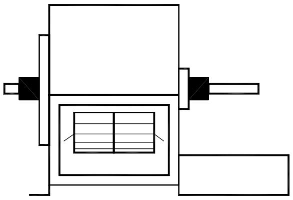
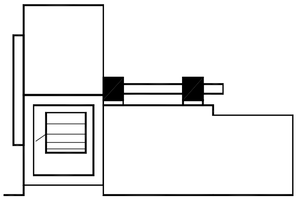
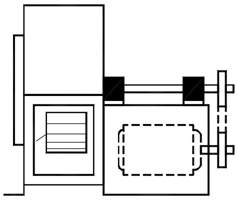
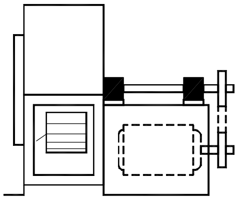
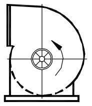
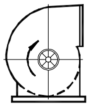
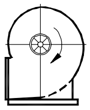
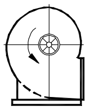
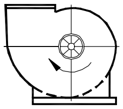
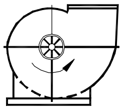
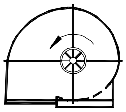
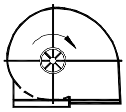
CHAPTER 6

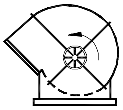
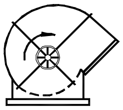
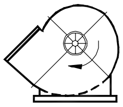
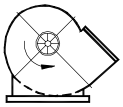
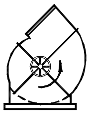
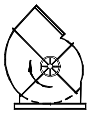
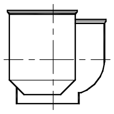
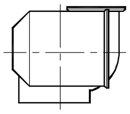
CENTRIFUGAL FAN SYMBOLS

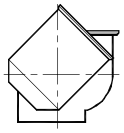
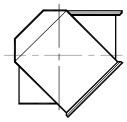
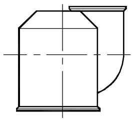
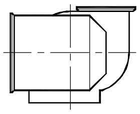
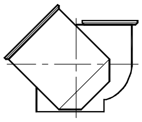
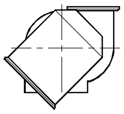
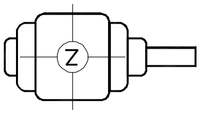
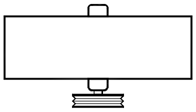
FILE NAME	SYMBOL	DESCRIPTION
FS001		Arr. 1 SWSI, for belt drive or direct connection. Fan wheel overhung, two bearings on base.
FS002		Arr. 2 SWSI, for belt drive or direct connection. Fan wheel overhung, bearings in bracket supported by fan housing.
FS003		Arr. 3 SWSI, for belt drive or direct connection. One bearing on each side and supported by fan housing.
FS004		Arr. 3 DWDI, for belt drive or direct connection. One bearing on each side and supported by fan housing.
FS005		Arr. 4 SWSI, for direct drive. Fan wheel overhung on prime mover shaft. No bearings on fan. Prime mover base mounted or integrally directly connected.

NOTE: For a more extensive library of symbols, including those for other disciplines, see Section UDS-06 Symbols in the National CAD Standard.

FILE NAME	SYMBOL	DESCRIPTION
FS006		Arr. 7 SWSI, for belt drive or direct connection. Arrangement 3 plus base for prime mover.
FS007		Arr. 7 DWDI, for belt drive or direct connection. Arrangement 3 plus base for prime mover.
FS008		Arr. 8 SWSI, for belt drive or direct connection. Arrangement 1 plus extended base for prime mover.
FS009		Arr. 9 SWSI, for belt drive fan wheel overhung. Two bearings with prime mover outside base.
FS010		Arr. 10 SWSI, for belt drive fan wheel overhung. Two bearings with prime mover inside base.

FILE NAME	SYMBOL	DESCRIPTION
FS011		Counter-clockwise top horizontal
FS012		Clockwise top horizontal
FS013		Clockwise bottom horizontal
FS014		Counter-clockwise bottom horizontal
FS015		Clockwise up blast
FS016		Counter-clockwise up blast
FS017		Counter-clockwise down blast
FS018		Clockwise down blast

FILE NAME	SYMBOL	DESCRIPTION
FS019		Counter-clockwise top angular down
FS020		Clockwise top angular down
FS021		Clockwise bottom angular up
FS022		Counter-clockwise bottom angular up
FS023		Counter-clockwise top angular up
FS024		Clockwise top angular up
FS025		Fan with top intake
FS026		Fan with horizontal right intake

FILE NAME	SYMBOL	DESCRIPTION
FS027		Fan with right angular intake from above
FS028		Fan with right angular intake from below
FS029		Fan with bottom intake
FS030		Fan with horizontal left intake
FS031		Fan with left angular intake from above
FS032		Fan with left angular intake from below
FS033		Motor
FS034		Fan

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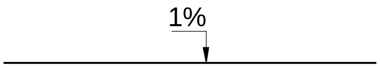
CHAPTER 7

PIPING SYMBOLS

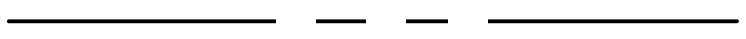
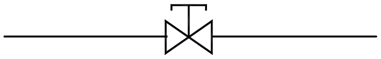
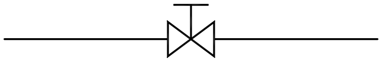
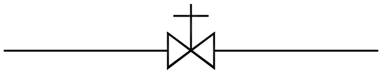
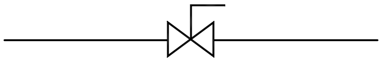
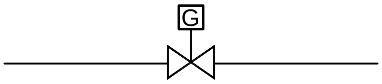
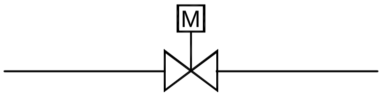
FILE NAME	SYMBOL	DESCRIPTION
PS001	——— SERVICE ———	Piping service
PS002	——— SERVICE S———	Piping service supply
PS003	———SERVICE R———	Piping service return
PS004	——SERVICE (DETAIL)——	Piping service detail information
PS005	— — — — — — —	Dashed line. For additional detail use for return, condensate, vent, and underground pipe.
PS006		Piping pitch
PS007	———SERVICE (E)———	Existing piping service
PS008	————V————	Vent
PS009	——— SERVICE (V) ———	Piping service vent
PS010	—✕✕— SERVICE —✕✕—	Pipe to be removed
PS011	———— C ————	Steam condensate service
PS012	———BBD———	Boiler blow down

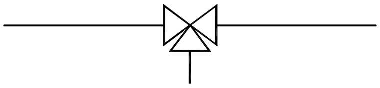
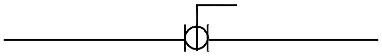
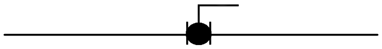
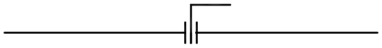
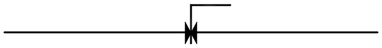
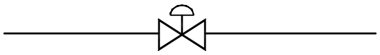
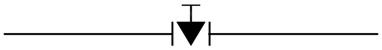
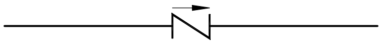
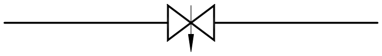
NOTE: For a more extensive library of symbols, including those for other disciplines, see Section UDS-06 Symbols in the National CAD Standard.

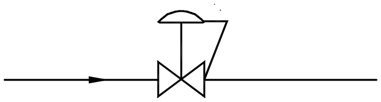
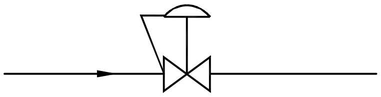
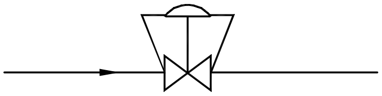
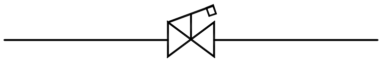
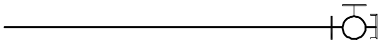
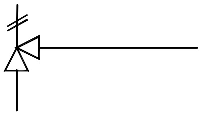
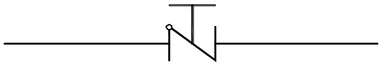
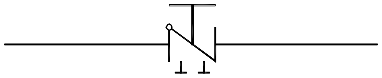
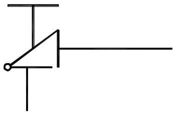
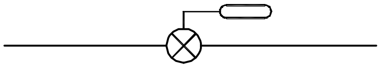
FILE NAME	SYMBOL	DESCRIPTION
PS013	———BFW———	Boiler feed water
PS014	———PC———	Pumped condensate or vacuum pump discharge
PS015	———VPD———	Vacuum pump discharge
PS016	———FOS———	Fuel oil supply
PS017	———FOD———	Fuel oil discharge
PS018	———FOR———	Fuel oil return
PS019	———FOV———	Fuel oil vent line
PS020	———FOF———	Fuel oil fill
PS021	———FOG———	Fuel oil gage line
PS022	——— HTWS ———	Hot water for heating supply
PS023	——— HTWR———	Hot water for heating return
PS024	——— A ———	Compressed air
PS025	———LPS———	Low pressure steam

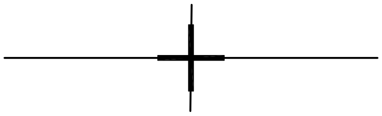
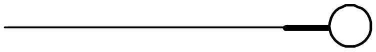
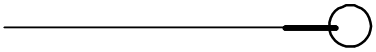
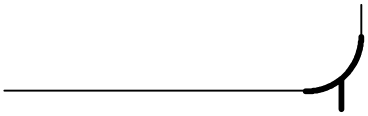
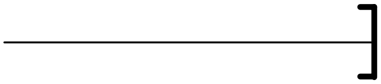
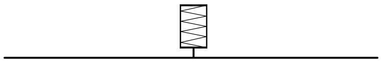
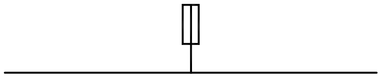
FILE NAME	SYMBOL	DESCRIPTION
PS026	———MPS———	Medium pressure steam
PS027	———HPS———	High pressure steam
PS028	———IA———	Instrument air
PS029	———VAC———	Vacuum service
PS030	———RS———	Refrigerant service compressor suction (cold gas)
PS031	———RL———	Refrigerant liquid line
PS032	———RHG———	Refrigerant hot gas line
PS033	———RLR———	Refrigerant liquid / gas recirculation line
PS034	———GHS———	Glycol heating supply line
PS035	———GHR———	Glycol heating return line
PS036	———CWS———	Condenser water supply
PS037	———CWR———	Condenser water return
PS038	———CHWS———	Chilled water supply

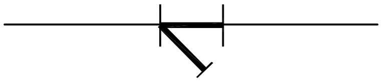
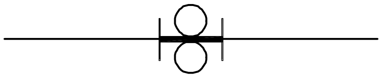
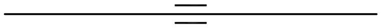
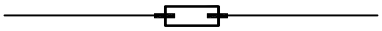
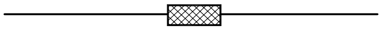
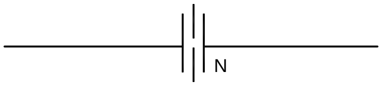
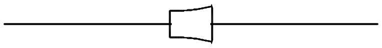
FILE NAME	SYMBOL	DESCRIPTION
PS039	———CHWR———	Chilled water return
PS040	———IW———	Indirect waste
PS041	———CD———	Condensate drain line (HVAC)
PS042	———HPWS———	Heat pump water supply
PS043	——— HPWR ———	Heat pump water return
PS044	———DTS———	Dual temp supply. Two pipe heating / cooling supply.
PS045	———DTR———	Dual temp return. Two pipe heating / cooling return.
PS046	———NPW———	Non-potable water
PS047	———SS———	Sanitary soil piping
PS048	——— SD ———	Above ground storm drain
PS049	———ACID———	Acid waste piping
PS050	——— AV ———	Acid vent piping
PS051	———W———	Waste

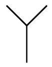
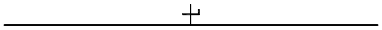
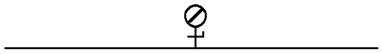
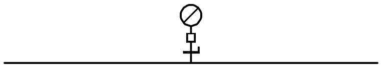
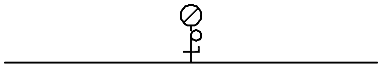
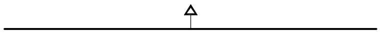
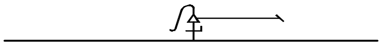
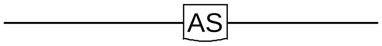
FILE NAME	SYMBOL	DESCRIPTION
PS052		Cold water, city water (potable/domestic)
PS053		Alternate cold water
PS054		Low Temperature hot water supply (potable/domestic)
PS055		Alternate hot water supply
PS056		Low temperature hot water return (potable/domestic)
PS057		Alternate hot water return
PS058		Natural gas service
PS059		Piping flow direction arrow
PS060		Lockshield manual valve actuator
PS061		Non-rising stem manual valve actuator
PS062		Rising stem manual valve actuator
PS063		Lever manual valve
PS064		Gear operated manual valve
PS065		Motorized valve

FILE NAME	SYMBOL	DESCRIPTION
PS066		Three-way valve
PS067		Ball valve
PS068		Closed ball valve
PS069		General symbol for special valve
PS070		Butterfly valve
PS071		Closed butterfly valve
PS072		Diaphragm valve
PS073		Closed diaphragm valve
PS074		Plug valve
PS075		Closed plug valve
PS076		Check valve
PS077		Spring loaded check valve
PS078		Needle valve

FILE NAME	SYMBOL	DESCRIPTION
PS079		Pressure regulator, pressure reducing from left to right
PS080		Pressure regulator, back pressure from left to right
PS081		Pressure regulator, differential pressure
PS082		Quick opening valve as used for blow down
PS083		Fusible link valve
PS084		Hose bib
PS085		Safety relief valve
PS086		Triple duty valve, combination shutoff, balancing and check valve
PS087		Triple duty valve, with measuring connections
PS088		Boiler stop and check valve
PS089		Refrigerant thermal expansion valve
PS090		Lateral
PS091		Tee

FILE NAME	SYMBOL	DESCRIPTION
PS092		Tee up
PS093		Tee down
PS094		Cross
PS095		Elbow, drawn with radius. Either radius bend or 90 degree line intersection is acceptable. Show reducing elbows by pipe dimension notation
PS096		90 degree elbow
PS097		45 degree elbow
PS098		Elbow facing up
PS99		Elbow facing down
PS100		Base supported below (elevation view)
PS0101		Pipe cap
PS102		Spring hanger
PS103		Thermometer well
PS104		Thermometer in a well

FILE NAME	SYMBOL	DESCRIPTION
PS105		Temperature and pressure tap
PS106		Y-type strainer
PS107		Double basket strainer
PS108		Pipe suction diffuser
PS109		Pipe guide
PS110		Pipe anchor
PS111		Piping ball joint
PS112		Piping expansion joint, expansion compensator
PS113		Piping flexible connection
PS114		Orifice flange with descriptive tag number or text information “N”
PS115		Venturi flow measuring device
PS116		Pitot device
PS117		Floor drain

FILE NAME	SYMBOL	DESCRIPTION
PS118		Funnel drain
PS119		Shutoff cock
PS120		Pressure gage, with shutoff cock
PS121		Pressure gage with snubber and shutoff cock
PS122		Pressure gage with pigtail and shutoff cock
PS123		Automatic air vent
PS124		Automatic air vent with manual release, shutoff cock, and discharge piping
PS125		Air separator

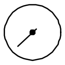
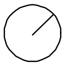
CHAPTER 8

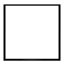
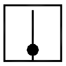
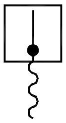
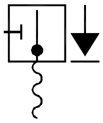
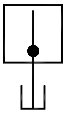
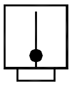
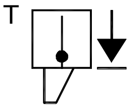
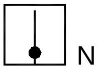
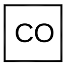
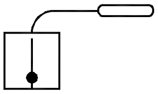
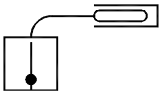
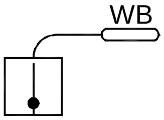
ENVIRONMENTAL CONTROL SYMBOLS

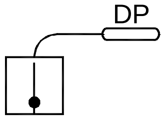
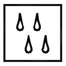
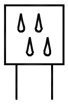
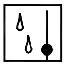
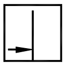
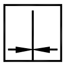
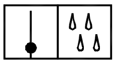
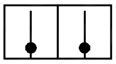
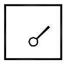
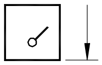
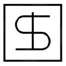
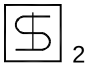
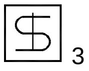
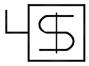
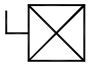
FILE NAME	SYMBOL	DESCRIPTION
CS001	MCC	Motor control center
CS002	HC	Humidity controller (pneumatic)
CS003	PC	Pressure controller (pneumatic)
CS004	TC	Temperature controller (pneumatic)
CS005	VSC	Variable speed motor controller
CS006	BDD	Back draft damper
CS007	EAD	Exhaust air damper
CS008	FBD	Face & by-pass damper
CS009	VXD	Fan inlet vortex damper
CS010	OAD	Outdoor air damper
CS011	RAD	Return air damper
CS012	VD	Volume damper (manual)
CS013	CS	Current sensor
CS014	△P	Differential pressure sensor (binary)
CS015	△PS	Differential pressure sensor (analog)

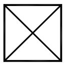
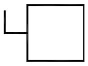
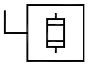
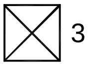
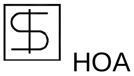
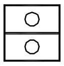
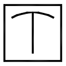
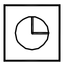
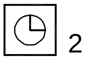
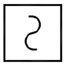
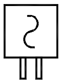
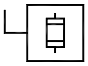
NOTE: For a more extensive library of symbols, including those for other disciplines, see Section UDS-06 Symbols in the National CAD Standard.

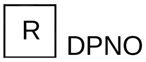
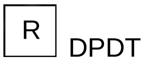
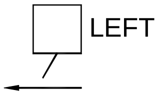
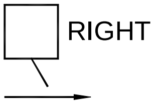
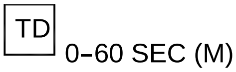
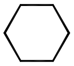
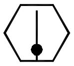
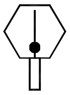
FILE NAME	SYMBOL	DESCRIPTION
CS016	FS	Flow sensor (turbine meter)
CS017	H	Humidity sensor (electronic)
CS018	P	Pressure sensor (electronic)
CS019	T	Temperature sensor (electronic)
CS020	VP	Velocity pressure sensor (electronic)
CS021	AFS	Air flow switch
CS022	HOA	Hand-off auto switch
CS023	$	Manual switch (electric)
CS024	PE	Pressure-electric switch
CS025	S/S	Start/stop switch
CS026	ES	Damper end switch (binary)
CS027	ΔP (LL)	Differential pressure switch (low limit) (binary)
CS028	ΔP (HL)	Differential pressure switch (high limit) (binary)
CS029	EP	Electro-pneumatic switch
CS030	TTT	Air flow measuring station
CS031	A	Alarm
CS032	EPT	Electro-pneumatic transducer
CS033	TLL	Low limit safety thermostat

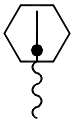
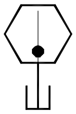
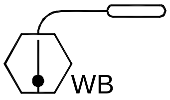
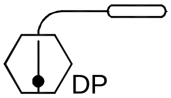
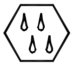
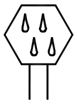
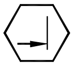
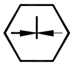
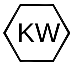
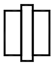
FILE NAME	SYMBOL	DESCRIPTION
CS034	MDM	Modem
CS035	STR	Motor starter
CS036	PR	Pneumatic relay
CS037	SD	Smoke detector
CS038	VXT	Vortex shedding air flow transmitter
CS039	H	Humidistat (space)
CS040	HC	Holding coil
CS041	S	Switch (pneumatic)
CS042	T	Thermostat (space)
CS043	T_x	Thermostat (space) night cycle
CS044		3-15 PSIG main air
CS045	20	20 PSIG main air
CS046		0-30 PSIG air gage
CS047	AO–X	Analog output (DDC controller)
CS048	AI–X	Analog input (DDC controller)
CS049	BO–X	Binary output (DDC controller)
CS050	BI–X	Binary input (DDC controller)
CS051	⊣	Manual reset

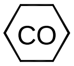
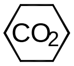
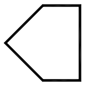
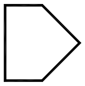
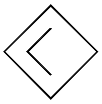
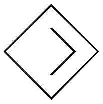
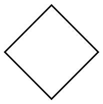
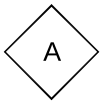
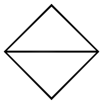
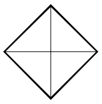
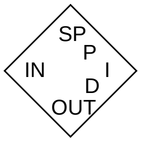
FILE NAME	SYMBOL	DESCRIPTION
CS052		High limit
CS053		Low limit
CS054		Controller
CS055		Wall mounted thermostat
CS056		Duct mounted averaging thermostat
CS057		Manually reset low limit thermostat
CS058		Pipe thermostat, well mounted
CS059		Surface and/or strap-on thermostat
CS060		Manually reset high limit duct mounted fire protection thermostat
CS061		Night thermostat
CS062		Generic controller, acronym denotes controlled medium
CS063		Remote bulb thermostat
CS064		Remote bulb thermostat in well
CS065		Wet bulb thermostat (use local language designator)

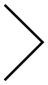
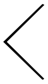
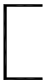
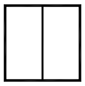
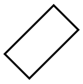
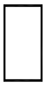
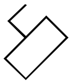
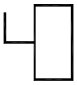
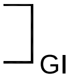
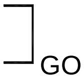
FILE NAME	SYMBOL	DESCRIPTION
CS066		Dewpoint thermostat (use local language designator)
CS067		Wall mounted humidity controller
CS068		Duct mounted humidity controller
CS069		Enthalpy controller
CS070		Pressure controller
CS071		Differential pressure controller
CS072		Combination temperature and humidity controller
CS073		Dual function and/or deadband temperature controller
CS074	UCM	Unit control module, more than a sensor or thermostat. May have an array of switches, indicators, and communication ports for controlling package units or terminal boxes. Subscript may denote variations.
CS075		Manual or setpoint adjustment “switch” (analog)
CS076		Minimum position switch
CS077		Two position switch, open-closed
CS078		Single pole-double throw switch
CS079		Three position switch
CS080		Single phase manual motor starter
CS081		Combination disconnect switch and magnetic motor starter

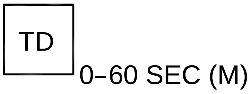
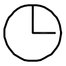
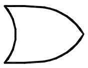
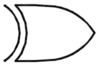
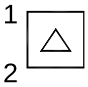
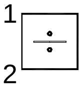
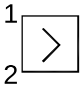
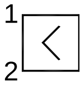
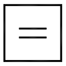
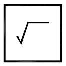
FILE NAME	SYMBOL	DESCRIPTION
CS082		Magnetic motor starter
CS083		Disconnect switch
CS084		Fused disconnect switch
CS085		Three pole contactor
CS086		Hand-off-auto switch
CS087		Momentary pushbutton
CS088		Maintained contact push button
CS089		Proportional manual controller
CS090		Variable speed drive controller
CS091		Time clock
CS092		Dual channel time clock
CS093		Control panel
CS094		Microprocessor control panel
CS095		Smoke detector
CS096		Duct mounted smoke detector
CS097		Relay, subscript denotes action
CS098		NO (single pole, Normally Open)
CS099		NC (single pole, Normally Closed)

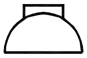
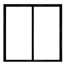
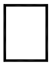
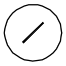
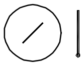
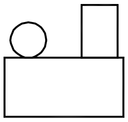
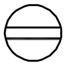
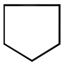
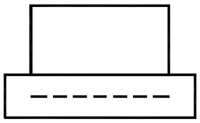
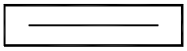
FILE NAME	SYMBOL	DESCRIPTION
CS100		DT (single pole, Double Throw)
CS101		DPNO (Double Pole, Normally Open)
CS102		DPDT (Double Pole, Double Throw)
CS103		Silicon Controlled Rectifier (SCR) electric heat controller
CS104		Flow switch
CS105		Flow switch
CS106		Interval timer (override or temporary operation) switch
CS107		Time delay relay
CS108		Time delay relay Example:(B): delay on break 0 to 60 second delay
CS109		Time delay relay Example: (M): delay on make 0 to 60 second delay
CS110		Controller, 3 to 5 ports B: Branch output M: Main power I: Primary Input R: Reset input (optional) C: Control point adjust (optional)
CS111		Single input controller with control point adjust port D: Direct acting P: Proportional control
CS112		Dual (primary and reset) input controller RA: Reverse acting PI: Proportional plus integral control
CS113		Sensor / transmitter / transducer / transformer
CS114		Wall mounted temperature sensor (“sensors” are broad range devices with no setpoint)
CS115		Duct mounted temperature sensor point sensing

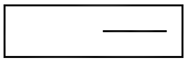
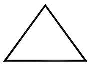
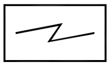
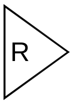
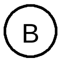
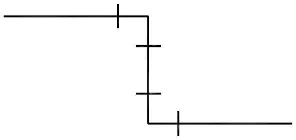
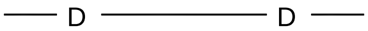
FILE NAME	SYMBOL	DESCRIPTION
CS116		Duct mounted averaging temperature sensing
CS117		Pipe mounted temperature sensor with well
CS118		Wet bulb temperature sensor
CS119		Dew point temperature sensor
CS120		Wall mounted humidity sensor
CS121		Duct mounted humidity sensor
CS122		Pressure sensor
CS123		Differential pressure sensor
CS124		Current transformer, amperage sensor
CS125		Kilowatt transducer
CS126		Fiber optic to cable modem
CS127		Voltage transducer (for instrumentation value)
CS128		Voltage transformer, step-down power
CS129		Pulse-width modulation driver
CS130		Telephone modem

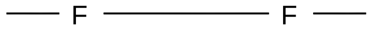
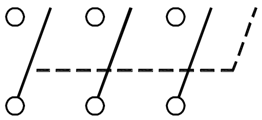
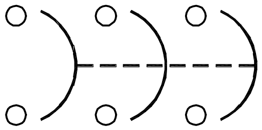
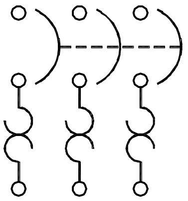
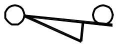
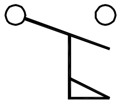
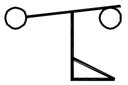
FILE NAME	SYMBOL	DESCRIPTION
CS131		Electric-pneumatic relay (solenoid valve two-position type output)
CS132		Electric-pneumatic transducer (variable pneumatic output)
CS133		Carbon monoxide sensor
CS134		Carbon dioxide sensor
CS135		Refrigerant gas sensor
CS136		Oxygen sensor
CS137		Analog controlled digital output (ACDO) output switches between 0 and 1 as analog input varies between two bounds
CS138		Digital controlled analog output switches between two analog signals as input switches between 1 and 2
CS139		Low signal detector
CS140		High signal detector
CS141		Signal reverser Output is maximum level minus input.
CS142		Average output is average of inputs
CS143		Sequencer, ratio relay, output goes 0 to maximum as input varies noted range
CS144		Ratio function, output varies between noted range as input varies between noted range.
CS145		Proportional-integral-derivative (PID) function, with "connections" for input, output, setpoint, and band/ gain adjustments for P, I, and D

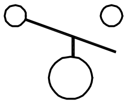
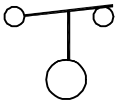
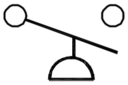
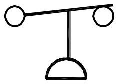
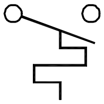
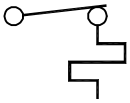
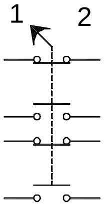
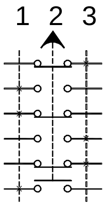
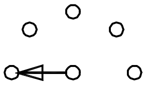
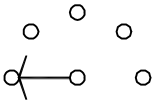
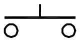
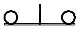
FILE NAME	SYMBOL	DESCRIPTION
CS146		Analog input function
CS147		Digital input function
CS148		Analog output function
CS149		Digital output function
CS150		Totalizer (pulse count) input
CS151		Software analog point An analog value created with a computer program which appears like a physical point to users other names: pseudo point, virtual point
CS152		Software digital point
CS153		Software commandable analog point A software value within a program which may be displayed with physical points and is easily changeable example: setpoint
CS154		Software commandable digital point A software status within a program which may be displayed with physical points and is easily changeable example: motor on-off
CS155		Global received analog input. Value received from another location via the communication network
CS156		Global origin analog input. Value output to other locations via the communication network
CS157		Global received digital input. State received from another location via the communication network
CS158		Global origin digital input. State output to other locations via the communications network
CS159		Constant value written into a program (changed by rewriting the program)
CS160		Parameter value used within a program which may be changed for program tuning

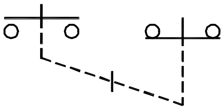
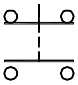
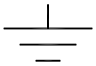
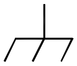
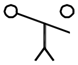
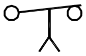
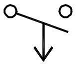
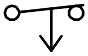
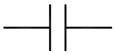
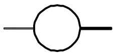
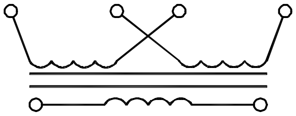
FILE NAME	SYMBOL	DESCRIPTION
CS161		Time delay. Digital transition from 1 to 0 is delayed a specified time. Example: (M): delay on make 0–60 second range
CS162		Time of day, value from real time clock
CS163		Date, value from real time clock
CS164		Day of week, value from real time clock
CS165		“And” output is true (1) if both inputs are true
CS166		“Or” output is true (1) if either input is true
CS167		“Exclusive Or” output is true (1) if either input is true but not both
CS168		“Add” output is sum of inputs
CS169		“Subtract” output is input 1 minus input 2
CS170		“Multiple” output is product of input 1 multiplied by input 2
CS171		“Divide” output is input 1 divided by input 2
CS172		“Greater than” output is true (1) when input 1 is greater than input 2
CS173		“Less than” output is true (1) when input 1 is less than input 2
CS174		“Equal” output is true (1) when inputs are equal
CS175		Square root output is square root of input

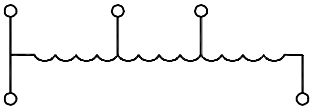
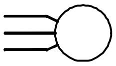
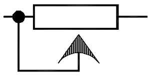
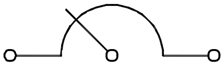
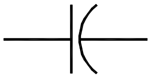
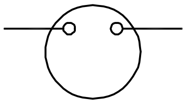
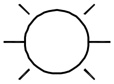
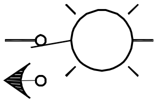
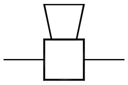
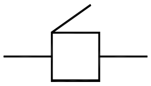
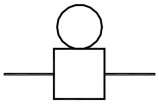
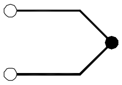
FILE NAME	SYMBOL	DESCRIPTION
CS176		Time schedule
CS177		Optimum start program
CS178		Ramp Example: a ramp function where a step increase of a signal from 0 to 100 causes a smoothly ramped output signal of 0 to 100 over a 180 second duration. A rapid drop in the input signal is not affected by the ramp (0 ramping time)
CS179		Actuator, spring return
CS180		Actuator, spring return with positive positioner
CS181		Actuator, floating
CS182		Actuator, two position electric spring return
CS183		Analog pressure indicator
CS184		Analog pressure indicator scaled for temperature indication
CS185		Air compressor
CS186		Air dryer
CS187		Moisture trap
CS188		Compressed air filter
CS189		Operator console (CRT, key board)
CS190		Printer

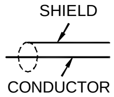
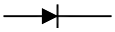
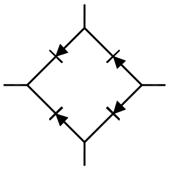
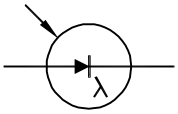
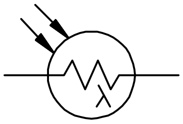
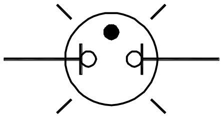
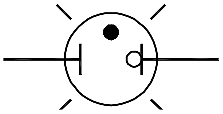
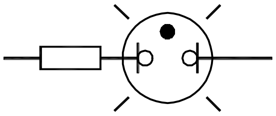
FILE NAME	SYMBOL	DESCRIPTION
CS191		Computer (pc)
CS192		Telephone output
CS193		Lightning protector
CS194		Repeater, communications
CS195		Main air
CS196		EP air (main air switched by an electric pneumatic relay)
CS197		Day-night air (air that varies between day and night cycles)
CS198		Summer-winter air (air that varies between summer and winter cycles)
CS199		Branch air
CS200		Pneumatic line restrictor
CS201		Pneumatic line
CS202		Line voltage
CS203		Low voltage, 48 volts and less
CS204		Number of slashes denotes number of conductors example: two low voltage conductors
CS205		Digital communication
CS206		Generic line

FILE NAME	SYMBOL	DESCRIPTION
CS207		Fiber optic line
CS208		Software, binary
CS209		Software, analog
CS210		Disconnect switch, three phase
CS211		Circuit interrupter
CS212		Circuit breaker
CS213		Normally open limit switch
CS214		Normally open, held closed limit switch
CS215		Normally closed limit switch
CS216		Normally closed, held open limit switch
CS217		Normally open flow switch
CS218		Normally closed flow switch

FILE NAME	SYMBOL	DESCRIPTION
CS219		Normally open liquid level switch
CS220		Normally closed liquid level switch
CS221		Normally open pressure switch
CS222		Normally closed pressure switch
CS223		Normally open temperature switch
CS224		Normally closed temperature switch
CS225		2-position selector switch (show open and closed poles as required)
CS226		3-position selector switch (show open and closed poles as required)
CS227		Rotary selector switch, five positions shown
CS228		Rotary selector switch with bridging contacts
CS229		Normally open pushbutton
CS230		Normally closed pushbutton

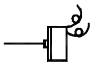
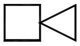
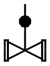
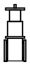
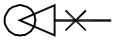
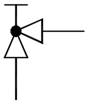
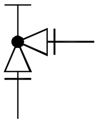
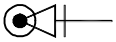
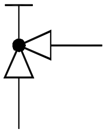
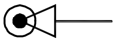
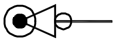
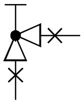
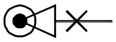
FILE NAME	SYMBOL	DESCRIPTION
CS231		Maintained contact pushbutton
CS232		Double circuit button
CS233		Ground connection
CS234		Chassis or frame connection (not necessarily grounded)
CS235		Plug and receptacle
CS236		Time delay relay contact after coil is energized (normally open)
CS237		Time delay relay contact after coil is energized (normally closed)
CS238		Time delay relay contact after coil is de-energized (normally open)
CS239		Time delay relay contact after coil is de-energized (normally closed)
CS240		Normally open relay or contactor contact
CS241		Normally closed relay, overload, or contactor contact
CS242		Coil for relay, starter, timer, or contactor
CS243		Solenoid coil
CS244		Thermal overload element
CS245		Control circuit transformer

FILE NAME	SYMBOL	DESCRIPTION
CS246		Auto transformer
CS247		3 phase motor
CS248		Resistor, heater
CS249		Rheostat
CS250		Potentiometer
CS251		Capacitor
CS252		Meter Example: volt meter
CS253		Fuse
CS254		Pilot light Example: red pilot light
CS255		Pilot light, push-to-test
CS256		Horn, siren
CS257		Buzzer
CS258		Bell
CS259		Thermocouple

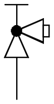
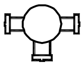
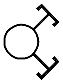
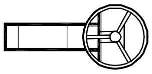
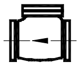
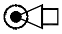
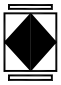
FILE NAME	SYMBOL	DESCRIPTION
CS260		Shielded couple. Show all conductors inside cable
CS261		Rectifier diode
CS262		Full wave rectifier bridge
CS263		Asymmetrical photosensitive cells
CS264		Symmetrical photosensitive cells
CS265		AC neon light
CS266		DC neon light
CS267		AC neon light with internal resistor

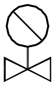
CHAPTER 9

FIRE PROTECTION SYMBOLS

FILE NAME	SYMBOL	DESCRIPTION
SS001		Flow switch
SS002		Speaker
SS003		Bell
SS004		Post indicator valve (PIV)
SS005		Open screw and yoke valve (OS & Y)
SS006		Angle gate valve, welded (plan)
SS007		Angle glove valve (elevation)
SS008		Angle globe valve, flanged (elevation)
SS009		Angle globe valve, flanged (plan)
SS010		Angle globe valve, screwed (elevation)
SS011		Angle globe valve, screwed (plan)
SS012		Angle glove valve, soldered (plan)
SS013		Angle glove valve, welded (elevation)
SS014		Angle globe valve, welded (plan)

NOTE: For a more extensive library of symbols, including those for other disciplines, see Section UDS-06 Symbols in the National CAD Standard.

FILE NAME	SYMBOL	DESCRIPTION
SS015		Angle hose valve (elevation)
SS016		Fire hydrant
SS017		Fire Department Connection
SS018		Butterfly valve
SS019		Check valve
SS020		Up and down sprinkler at same location
SS021		Up sprinkler
SS022		Pendant sprinkler
SS023		Upright sprinkler or rise (sprig)
SS024		Pendant sprinkler on drop
SS025		Sidewall sprinkler
SS026		Piping (lines) ½ width of main
SS027		Piping (mains) two times width of lines
SS028		System riser
SS029		Hose valve (angle valve)
SS030		Preaction valve
SS031		Deluge valve

FILE NAME	SYMBOL	DESCRIPTION
SS032	○	Rise up on piping
SS033	●	Drop in piping
SS034		Tamper switch for valves

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APPENDIX A

CAD PROJECT PROTOCOL

A.1 INTRODUCTION

The audience for this document is the SMACNA member who has been successfully using a CAD system in-house to prepare his own design and fabrication drawings. The member is now facing the next step with his CAD system.

You may ask yourself—Why should I go any further with CAD? After all, my company is using CAD effectively to make the drawings we need to make and now we're making them much more productively than we did on the boards (or maybe we aren't, which raises other questions). We went through a long, expensive learning curve to get this far with our basic CAD system. Why should we do any more? Why not just continue to exploit our current productivity gains and settle for that?

Today's CAD systems can be used for far more than just drawing lines onto your computer screen. If you are only using your system for electronic drafting, you are missing out on the greater part of CAD's potential to make your life easier. You are missing opportunities that some of your competitors are already exploiting.

What can someone who is already using CAD successfully gain by going further? Among other possibilities, you can:

- use CAD with application software to automate complex and repetitive design calculations
- pass the design drawings you make with your CAD system into a CAM system that will be a real part of your fabrication process
- qualify for projects that require sheet metal and air conditioning contractors to:
- receive and use CAD files during the design process
- deliver CAD files to the general contractor or project owner at the end of the project.
- receive CAD files from other members of the project team and use them to save yourself work
- use CAD to offer additional services or useful data to the general contractor or project owner

In addition to changes that are taking place within the operation of an individual contractor or within the team for a single project, industry-wide initiatives are underway which will influence the way automated systems are used in projects.

The Industry Alliance for Interoperability is pursuing its goal of enabling interoperability in the AEC industry. A current project will define how electronic models of project work will be developed within computer systems and then how the this model will be used and shared among the members of a project team. The goal of the project is that the electronic model and the information it contains will be easily accessible to every member of the project team and that every member will be able to add his own work input to the model in a way that the rest of the team can easily read. The IFC (Industry Foundation Classes) Specification that describes how this process might work is under development right now.

The Industry Alliance for Interoperability's Project Model Specification is only one of the initiatives currently being considered or developed. Other professional organization are developing their own approaches. Initiatives are being developed in other industries.

Your computer system is going to let you work in greater harmony with the other members of your project teams. You will be able to work quicker, more efficiently, more accurately, and with fewer wasted motions.

You can realize benefits by using your CAD system more creatively, more aggressively. At the same time, extending CAD beyond the your own company presents some additional considerations, some additional challenges.

This document will:

- describe ways you can extend CAD use to boost productivity and qualify for more projects

- describe the new issues you must consider when extending CAD use
- offer suggestions for a CAD standard that will help you take on more challenging CAD projects

A.1.1 Engineering/Owner Needs

The use of CAD in the sheet metal contracting sector of the construction industry has a long history. For example, sheet metal firms have been using computerized manufacturing systems to custom-fabricate duct systems for years. Sheet metal firms have needed to coordinate their work with other contractors for many years, since duct work is traditionally the largest system. Naturally, that need transfers developing and exchanging electronic drawings.

Specialty contractors, especially mechanical, sheet metal, electrical, and fire protection firms play the most important role for facility managers because it is the HVAC, plumbing, electrical, and fire protection systems which control the comfort and life safety of the building.

Energy efficiency, indoor air quality, and occupant comfort and productivity are all by-products of the systems installed by HVAC, electrical, and fire protection contractors.

It is the services of the specialty contractors who use the latest technology in data and system development and installations that fulfill the long term operating needs of the building owner.

A.1.2 The Beginner’s CAD Standard

Beginning CAD users tend to use their CAD systems primarily to meet their own internal needs. If the CAD files they create are sufficient to get the job done internally, then that’s all they need and they are happy. Since the average beginner’s CAD use is purely in-house, his CAD staff can develop an in-house CAD standard that meets their own needs and they need not be concerned about how their standard fits with anyone else.

An in-house CAD Standard should include:

- procedures for planning, budgeting, and organizing project CAD work
- working procedures
    - staffing and scheduling
    - order of work
    - quality control.
- standards for layering CAD work
- standards for naming layers and other entities
- libraries of symbols, details, sheet borders, etc.
- custom menus and other modifications to the user interface to make an out-of-the-box CAD system specifically fit the user’s projects and methods
- LISP routines and similar pieces of small-scale programming to make it easier to produce the work
- procedures for documenting ongoing and completed work
- procedures for archiving completed work

Caution

If your company does not have standards for its CAD work, your CAD work will probably be inconsistent, hard to re-construct in case of a question, and difficult for anyone but the original creator to decipher.

Consistently followed written standards are the minimum requirement.

Management should approve and actively support these standards. Compile them in written form. Make sure all members of the CAD staff understand and abide by them.

The specific details of your CAD Standard become much more important when you start to use your CAD systems in more sophisticated ways and when you have to coordinate your CAD work with other members of the project team.

A.1.3 Standards for Use With Other Software

As you start to use your CAD systems for more than simple graphics, you often want to coordinate your CAD work with other software. This might include libraries of parts, equipment, and details available from professional associations like SMACNA, from vendors, or from project standards. It might also include design application programs that will work directly with the CAD system or exchange project data with the CAD system (extracting CAD data from project files, making calculations, preparing analyses, and perhaps even inserting data back into the CAD files).

Examples of this application software include programs for:

- performing energy analysis of a design
- calculating heating and cooling loads
- calculating duct pressure and air-flow through a system
- calculating duct sizes
- producing bills of materials
- estimating quantities and costs
- value engineering
- estimating or monitoring service and maintenance requirements and activities
- coordination with automated fabrication equipment (CAM programs)

When using such design software, you must typically prepare your CAD work so it will coordinate with the design software. For example:

- you may have to organize CAD work in a prescribed file structure for the design software to work properly
- you may have to draw graphic elements in specific layers or levels
- you may have to draw elements in a specific sequence or use specific commands to draw them
- you may have to use specific symbols drawn from libraries provided by the design software publisher (or, the design software may automatically place the symbols on your drawing)

- design software often requires you to work through the software in a specific order

Using design software often requires you to revise the CAD Standard that served you well when you were only producing simple graphics in-house. Your updated CAD Standard must recognize the requirements of your new design software and produce data in formats that the design software can use.

A.1.4 Standards that include Project Requirements

You will eventually encounter opportunities to work on projects in which the other project team members expect to exchange CAD files during the project, and you will be required to deliver CAD files to them or receive files from them at one or more points during the work.

In such cases, you may not be able to use your in-house CAD Standard or you may have to modify it to meet project requirements.

When becoming involved with such projects, you typically learn that the project has its own CAD Specification which you must follow while doing the project work. The CAD Specification is not the whole CAD Standard. It addresses the structure of the work to be done and the procedures for exchanging files between project team members, but it does not govern internal procedural issues (though its requirements may be such that you will have to modify your internal procedures to meet it).

Still, the Project CAD Standard is very important and can greatly influence how you will perform project CAD work. Since it affects how and when you will perform the project CAD work as well as the content of the CAD files you will receive and later deliver, the Project CAD Standard can significantly affect how much time and money it will cost to do the project CAD work.

> ***Caution***
>
> *If you are required to follow a Project CAD Specification that is different from the one you usually use, this can significantly affect what it will cost you (in time and money) to perform project CAD work.*

The Project CAD Specification can have many origins.

Designer. The Project CAD Specification may start with the original CAD drawings prepared by the project designer. You may just be required to follow the CAD spec the project architect or engineer adopted at the beginning of the project for his own reasons. This CAD spec may not fit your needs at all—it may even make it harder for you to do your own work.

- ***Contractor/Construction Manager.*** The Project CAD Specification may come from the project's general contractor or construction manager. It may have been developed to address the needs of the general, the construction manager, and the subcontractors who will be exchanging CAD files during the project. In such a situation, the project CAD spec may be a closer fit to your own in-house CAD Standard.

- ***Owner/End User.*** The Project CAD Specification may have been developed to assure that the finished CAD files will work with a specific planned post-design or post-construction use for the CAD files. The project owner or general contractor may require that your CAD files fit into a particular project CAD specification to produce CAD files formatted to:

  - develop an overall project quantity take-off and cost estimate
  - fit into an automated project management program that will let the general contractor or construction manager plan, schedule, monitor, and coordinate the project work
  - populate the databases required for a facility management system
  - establish an automated maintenance or material handling system

Wherever the Project CAD Specification originates, you must take time before you sign any agreements to study and evaluate the CAD spec. You must understand how the CAD spec will affect your work, your costs, and your schedule before you agree on a price for the work.

A.2 REQUIREMENTS

Suppose you have been using CAD successfully in-house to produce your project drawings. What can you expect to encounter when you start working on projects that require you to exchange files with other project team members?

A.2.1 Project CAD Specification

Early on in such a project, you will be faced with a Project CAD Specification. This document describes how the project CAD work is to be done. Among other things, a Project CAD Specification should include descriptions of:

- **System Elements**
    - Hardware definition
    - Operating system—name and version number
    - CAD software system definition—name and version number
    - Other required application software
    - Delivery medium
- **Design Elements**
    - Directory and file structure
    - Drawing names and descriptions
    - Reference file structure
    - Saved views/windows
    - Layering/leveling conventions
    - Entity naming conventions
    - Line types, weights, and colors
    - Pen tables
    - Text fonts and sizes
    - Symbols and other library materials
    - Drafting Standards
- **Procedures**
    - Number of and schedule for submittals
    - Contents required for each submittal
    - Procedure for each submittal
    - Procedures for submittal review an acceptance

Caution

> *Can you meet the requirements of the Project CAD Specification? Don't make assumptions. Don't take anyone's word for it. Verify that you can meet the spec. Run tests. Do it before you sign an agreement.*
>
> *If you can't meet CAD specification requirements, figure out what it will cost you to acquire the required capability—all costs: hardware, software, installation, training, learning curve, etc.*

You will have to deal with a CAD specification for every CAD-based project you work on. Setting up to follow a required project CAD spec means that you must modify the CAD Standard you developed when your company was just using CAD in-house. The Project CAD Spec may be similar enough to your own CAD Standard that you will only have to make minor changes. However, the Project CAD Specification may be so different from your Internal CAD Standard that you will have to make radical changes.

In either case, setting up to follow a Project CAD Specification will cost more than it did to just follow your own CAD Standard back when you didn't have to exchange CAD data with anyone else. The cost may be relatively minor, or it may be significant. Either way, you must evaluate the project CAD Specification and estimate how much extra time and money it will cost you to follow it. You must know your likely costs when you prepare your cost proposal.

If you work on a lot of your projects with the same team and encounter a consistent CAD specification for most of these projects, your CAD costs should be relatively similar from project to project and it should be relatively easy for you to estimate these costs. If you work on many different project teams and face a different CAD spec on almost every project, your CAD costs will be significantly higher and estimating these costs will require additional effort.

Are you involved in a CAD project that does not have a Project CAD Specification? Don't let that fool you. Eventually someone will decide that the required project CAD files will be useless unless they are prepared to meet standard. In many such cases a Project CAD Specification is imposed after the work is underway. Everyone is then expected to modify their completed work to fit the newly-announced CAD spec. That's an additional cost, and probably a delay, as well.

Caution

No announced Project CAD Specification? You're not off the hook!

Eventually somebody will decide what they want and tell you what CAD specification you have to meet. Your best bet is to determine the CAD spec requirement before work starts.

Let's look at some of the big issues included in CAD specs and see how they can affect your CAD system and your work.

A.2.2 Hardware

The Project CAD Specification seldom requires that the CAD user use specific hardware. Instead, the goal of the people establishing the CAD spec is to assure that every member of the project team will be able to read the electronic files it receives and will be able to submit electronic files that the other team members can read—and to assure that whoever establishes the requirement gets files in a format he can use.

There are currently three main types of computer hardware being used to run CAD software:

A.2.2.1 Workstations

These are systems from vendors that include Bentley, Compaq, Hewlett Packard, Silicon Graphics, Sun Microsystems, and others. Most of these systems are quite powerful and designed to deliver high performance on demanding graphics applications (such as digital terrain modeling or 3D rendering). Most of these systems operate proprietary RISC-based processors and work on different versions of the UNIX operating system.

A.2.2.2 PC-compatible systems

IBM made its Personal Computer (PC) system in the early-1980's and this system was soon accepted as an industry-wide standard. Since the PC system became the standard, many other vendors have developed computers that operate on the original IBM standard. This family of computers is called "PC-compatible." These computers were originally developed for non-graphic applications, but they have since evolved to the point where some PC'S are powerful machines that can handle any graphic task. Most PC-compatible systems run under versions of Microsoft Windows.

A.2.2.3 Apple Macintosh systems

Apple has produced Macintosh systems since the mid-1980's and these systems have always been popular for use with graphic applications. Macintoshes run under the Macintosh operating system.

The majority of today's CAD stations are PC-compatible computers, but they are not necessarily better than workstations or Macintoshes. For the purposes of this booklet, the most important differences between these systems are:

A.2.2.4 File compatibility

Many CAD and application programs offer versions that will run on more than one hardware system. Files generated by program versions that were designed for different hardware platforms may not be fully compatible with one another. For example, a CAD user whose CAD program runs on a PC CAD station may not be able to read a file generated by the Macintosh-based version of the same CAD program unless a conversion or translation process is performed.

A.2.2.5 Software availability

Not all programs offer versions to run on all common hardware platforms. Furthermore, programs with versions for each hardware platform may not have all versions of the program upgraded to the same revision level. For example, a user who has a different hardware platform than that described in the Project CAD Specification may have the required CAD software, but may not be able to find a required application program written for his hardware or may find that the version of the program that will run on his hardware is not the most current revision of the program (and may be missing required features, line styles, fonts, or other recent updates).

If you do not have the same hardware that is described in the Project CAD Specification, you may still be able to produce the required CAD work, but you must verify a few things before the project starts:

- Can you read the files you will receive from the general contractor or other project team members?
- Can the general read the files that your system produces?
- Can you acquire the necessary revisions of all the software required by the CAD spec?

Determine the answers to these questions before you determine a price or agree to do the work. Run some tests. Pass some sample files back and forth and see if they work. It's much easier to invest some time in testing before the work begins than it is to wait until the day before you are supposed to deliver a big submittal and then discover that something doesn't work.

A.2.3 Software

A Project CAD Specification may require you to receive CAD files or deliver them in the format of a specific CAD program. If you are to work as a member of the project team and communicate effectively with the other team members, this requirement is important. In essence, this requirement establishes the language that will be spoken by the team during the project. If you meet the requirement, make sure you have both the specific CAD program required and required revision of that program.

The issue of revision number is important because different revisions of a program may not necessarily communicate easily with one another. For example, AutoCAD Release 14 and AutoCAD 2000 write design files in slightly different formats. AutoCAD 2000 can read files produced by Release 14, however Release 14 cannot read portions of AutoCAD 2000 files that contain object types that are not supported by Release 14.

In addition to specific CAD software, a CAD specification may require application software for use with the CAD software. These applications may include working environment software such as Autodesk's Architectural Desktop or software that performs specific design calculations like the products developed by QuickPen.

You may be able to substitute for a required software application, but don't assume anything. If you plan to use anything other than the program and version number that appear in the CAD spec, run enough tests before work starts to assure yourself (and convince your client) that your alternative will work and produce results that the rest of the project team will accept.

A.2.3.1 Alternative or Compatible Programs

Encountering a CAD specification that calls for different tools than you already have, you may fall for the "compatible program" fallacy. You may be tempted by the vendor's assurances that your program and the required program are "compatible," that you can use your old tools and methods to produce the CAD files and then "translate" them to meet the CAD spec's requirements.

Caution

Exercise caution whenever you hear the word COMPATIBLE applied to computer hardware or software.

Very few products are really fully compatible. Don't assume anything. Don't take anyone's word for it. Test all claims of compatibility.

Some CAD programs can accept files produced by other CAD programs—either directly, or through an intermediate file format like .DXF. Data files can be passed back and forth between CAD programs and one program can actually display another program's files. However, this "compatibility" of file formats constitutes a "translation" only if your expectations are modest.

Suppose a project CAD specification requires that data files be prepared with a CAD system you don't have. If you plan to use your current CAD system to produce your project CAD work, to follow your current internal CAD Standard, and then "translate" the files into the format of the required system in order to satisfy the required CAD spec, you may be in for trouble. You will probably have to spend a lot of time massaging your CAD files to get them to fit into the required file format and meet the requirements of the project CAD spec after the fact.

If you must do the work with your current CAD system and deliver files in the format of the required CAD system, you must plan your work carefully and plan it for the eventual translation. You must plan which line-styles in your CAD drawings will correspond to which of the required line-styles in the files you will deliver. You must do the same kind of planning for colors, line-weights, layers/levels, fonts, symbols, etc. Each line you draw with your own CAD system must be drawn to fit into your plan for the eventual translation.

Once you complete the CAD work with your own CAD system and then translate the files into the required format, you must check your new files to be sure that everything translated as you planned and that they satisfy the project CAD spec. You must do this before you transfer electronic files to anyone else. This final step is just an elementary quality control measure. Chances are that you will have to do some clean-up work after the translation. You may be able to hire someone else do your checking and make your corrections or you may have to get a copy of the required CAD program yourself, just so you can perform the quality control checking.

This may sound like a lot of work—it is! In order to use your own CAD system and submit required project files in the format of a different CAD system, and follow the Project CAD Specification, you must:

- Plan your work to minimize translation problems
- Do your CAD work following the revised project CAD spec designed in the previous step
- Make the file translations
- Check the translated files and correct any errors that occurred during translation

You will have to perform the last two steps both for your final submittal and for every intermediate submittal during the project. This means significant time, effort, and expense.

Caution

Translating complex files between CAD systems is difficult—no matter what anyone may tell you. Avoid translations whenever you can. On a big project it may be worthwhile to buy and learn the required CAD system instead of trying to do the work with your current system and translate files.

A good working definition of "compatible" software systems is "different." Translating complex CAD files to meet a specific CAD specification requires much more work than the vendors want you to think. Wherever possible, use the required CAD program to do your work.

A.2.4 Networking

Networking is typically done within a company and it does not often touch on a company's relationships with other project team networks. Networking offers many ways to improve productivity and team coordination as CAD users can:

- easily pass electronic files back and forth—no more sneaker-netting
- access consistent centralized libraries of symbols and details
- share a single file among multiple users at the same time
- let users view files from other team members as reference files and coordinate work between teams
- let users share peripherals such as printers, plotters, mass storage, CD drives, etc.

In-house networking also poses some challenges:

- large storage devices require large, complex data structures that need careful planning
- administering and managing files on shared data storage devices requires ongoing effort
- access of individual users to specific files or groups of files must be controlled
- protocols must be developed for sharing files among project team members—checking files in and out and sharing changes on an equitable basis

Technology and management tools exist to address these challenges and they are all solvable.

If, however, you must participate in some kind of team-wide network the scope and scale of these challenges increases and several other problems arise.

Wide Area Networks (WAN's) that can link several project team members in different locations pose solvable technological challenges, but these are beyond the scope of this booklet. The most important concern about working on a WAN is that if you and other project team members share a network that contains everyone's CAD files, you must be very careful about when and how the files are exchanged among the team members.

Some enthusiasts paint a rosy picture of a project environment in which everyone has constant unlimited access to everyone else's work all through the life of the project. This can be confusing and dangerous.

Putting it simply:

- You don't want to use another team member's CAD files until he is ready for you to use them (when his quality control procedures are complete and the files are ready for release). Otherwise, you may access an incomplete file or one that contains a design option that is still not final.
- At the same time, you don't want anyone using your CAD files until you feel they are ready.

Caution

Don't exchange CAD files with other project team members until everyone agrees that the files are ready to share.

Agree in advance how any shared files can be used (and how they should not be used).

This simple precaution will prevent misunderstandings and wasted efforts.

In the days of manual drafting, team members were protected by the fact that they exchanged hard copies of drawings and that were accompanied by transmittal letters and other documentation. When project team members work on a shared network, they need tools to prevent access to their drawing files until they are ready for others to use them and other tools to help them determine when and how the files will be exchanged.

A.2.4.1 Security

CAD file security is a serious issue—whether you are working on an in-house network or on some larger project-wide network. The critical issues involve protecting files from unauthorized access by either your own staff, other members of the project team, or outsiders who may intrude into a network.

Tools to address these problems are available, but they do not fall within the scope of this booklet. The important thing is to be aware that security questions are real issues that must be addressed.

A.2.4.2 Access

It is important to determine who should have access to which files in your CAD system, what kind of access they have to which files, and when during the life of the project they have this access. Some people are quite concerned about hackers and other parties gaining malicious access to their files. Certainly this is a legitimate concern.

Just as important, though, are concerns about non-malicious access to your files. These are concerns about people who are legitimate members of your project team who may gain access to portions of the project files that don’t fall within their responsibility, or just getting access to files before or after their part of the work is executed.

For example:

- You may not want some of your CAD users to have any access at all to certain files. Information in these files may be confidential or the person may just have no business looking at certain files.

- You may want to make files available for some team members to see at any time during the project, but you may only want them to be able to edit the files during a specific phase in the course of the project.

More frequently, though, you will want to give most of your users enough privilege to call up project files and view, examine, copy, or plot them—but not enough privilege to modify them (this is often called *read-only access*). In addition, you will want to grant specific people access privilege that will let them edit the drawing files for which they are responsible (*read/write access*).

Many project team members will have read-only access to most of a project’s files and read/write access to only some of the files. For example, in a multi-disciplinary design firm a mechanical engineer may have read-only access to all project drawing files and have read/write access only to the mechanical drawing sheets.

You will probably want to give the team read-only access to the reference files that describe existing conditions.

Network administrators generally have software tools at the operating system level that let them manage permissions and levels of file access for the various members of the project team. These tools don’t operate themselves, though. The greater challenge is for the project management team to plan the project work and develop an overall scheme for allowing access to the files—and then to convey and explain this to the project team members.

One relatively painless way to control file access is with viewing software. Viewing utilities let users view and plot project drawing files. Users can even add comments and marks to a drawing in the form of electronic red-lining or post-it notes. These marks are stored separately and do not modify the drawing file at all.

Many viewing programs include document management features. Some let you assign several fields of non-graphic descriptive information to the drawing files—drawing names and numbers, drawing descriptions, release status, dates, names, etc.—and then use this data to organize, sort, and find project files. Some let you track revisions to your drawing files—logging every time someone accesses each file, logging that person’s identity, giving the user a place to enter a verbal description of all work done during the work session.

As an added bonus, viewing software is generally easier to use than CAD software and viewing software lets you access project files without having to own an expensive CAD software license. This is a cost-effective way to give a checker or supervisor access to project drawing files that he will not be changing.

A.2.4.3 Revision Control

The content of project drawing files changes from day to day as CAD users work on them.

It is easy to make a copy of a drawing file at any time. There are many good reasons for making copies, *e.g.* you may decide make a copy of a file to test an alternate design without modifying the original design, or you may make a copy on which a specialty consultant will do his design work. As a result, copies of files proliferate.

Often a CAD project manager discovers that the network directories contain several different copies of a drawing file (and who knows how many copies have been written onto disks and carried away for use elsewhere?). Every copy is a little different from every other one.

> **Caution**
>
> *Take pains to keep track of which version of your electronic files are "current." Keep track of which copies are "current" and also track which copies are made for other purposes—record copies, archives, design alternative testing, reference files, etc.*
>
> *This bookkeeping requires significant effort, but it is easier than much less stressful than re-creating a "current" file after you have lost track.*

After considering the matter for a while, the project manager realizes that he doesn't know which file represents the "real" and current design. He may even find that no single file contains all of the real or current design. Instead, each of several drawings files on the network contains a portion of the real design, but not all of it. He faces a real challenge gathering up all the portions of the real design that have been developed separately and combining them into a single drawing file where all the changes fit together.

A smart project manager only has to experience this confusion once or twice before he realizes that revision control is an important issue. It is critical to track each drawing file through its life and the life of the project. The person who manages the project CAD work must:

- track which version of a file reflects the current design
- track file copies that are made to test alternatives or for other purposes and make certain that they do not get confused with the current drawing
- when an alternative from a file copy is adopted into the project design, he must manage its incorporation back into the "real" project files
- purge or archive invalid or outdated copies of files
- keep track of drawing files that are distributed outside of his network, trying to determine who has up-to-date copies of the files

This may seem like a daunting task, but it is do-able. This is an administrative and management challenge. Most important in implementing such a program are consistent visible support from company management and cooperation of the company's CAD users.

A.2.4.4 Record Drawings

Project drawing files evolve and change through the whole life of the project. At different points during the project, project team members make interim submittals of their drawings. These submittals typically include copies of their drawing files as they stand at the time of the submittal. Once the submittal is made, project work continues and the active working drawing files continues to change.

Caution

Keep archived record copies of everything you receive from other project team members and of everything you send to them. Document these exchanges.

This is a basic project management/quality control measure. It is important in a hand-drawn project and it at least as important when you use a CAD system.

It is important to make copies of your drawing files as they were at the time of the interim and final submittals and save them as project archives. Note that the "final" submittal seldom marks the end of the project, so you must also keep a copy of the final submittal in case later CAD work is done to change the current files.

These archives become your record copies of just what you submitted with each interim file exchange. This precaution can protect you if a problem should arise and there are questions about who had what information and when they received it. You will be able to consult your record copies and answer these questions.

Caution

Don't rely on electronic files as your long-term project archives. They won't last forever.

If you are going to maintain project archives of your solutions, you must plan your archives carefully. Although long-term electronic storage media is improving, your electronic files won't last forever. Compact Disk (CD) technology offers the most hope for a cost-effective solution to archiving project files. Unrecorded CDs have a typical shelf life of 5 to 10 years. Once files have been written to a CD manufacturer claims for integrity increase to maximums of 70 to 200 years, provided that the CDs are stored in an environment that meets their specific requirements. The American National Standards Institute has begun some work to substantiate such claims.

On the surface this is great news. Unfortunately, the more daunting problem is archiving the system required to read your old drawing files. The rapid obsolescence of computer systems is the greatest obstacle to the long-term retrieval of your files. To be able to retrieve and edit your project files you should be ready to save the computer that created them, its operating system, your CAD software, and any utility software that you used to prepare the drawings.

Caution

If you do need to archive electronic files on a long-term basis, then be ready to archive the computer system that you used to produce the files.

Even if you do go to this length to set up your electronic archives, your current best bet is that your paper copies of your drawings will still probably outlast your electronic drawings. Because of this, your archive must include hard copies of all the drawings you plan to store as electronic files. Full-size reproductions, photo reductions, or microfilm are possible storage media. Thus, if you ever do need to retrieve a project file and it does turn out to be corrupted, you can at least scan your paper drawing, perform a little optical character recognition on it, and not experience a total electronic loss.

If you are fortunate enough to successfully retrieve your electronic archive, your drawings can still be useless to you unless your archive includes:

- careful documentation of your electronic files that will let someone open the files years after the project is complete and find their way around the files (documentation should include descriptions of: the directory and file structures, how the drawing files correspond to the plotted drawings, reference files, saved views, and anything else that might be useful)
- copies of transmittal documentation to indicate who received the files and when they received them
- a copy of the project CAD specifications

Caution

Consider your own business, estimate your liability exposure, and decide how much archiving and documentation is necessary.

As a minimum, archive all official submittals. Archive other interim file exchanges as seems necessary. When in doubt, use caution.

A.3 EFFECTIVE CAD MANAGEMENT

CAD systems offer the greatest benefits when they are effectively managed (and they can punish weak management). Good CAD management can pay for itself early in a company's CAD involvement, even if the company just uses CAD internally and is not yet exchanging CAD files with other project team members. Even in these early stages of CAD use, good management can:

- help a company develop a CAD Standard that will let it do better CAD work
- help a company keep its CAD work well-organized and efficient
- motivate a company's CAD users to work consistently
- let a company measure and monitor CAD productivity
- help the company achieve non-project goals like developing libraries and customization tools

A.3.1 CAD Project Standard

Develop and adopt a company-wide CAD Project Standard to assure consistent CAD work. Do it thoughtfully.

Caution

Don't start CAD work in your company without a company-wide CAD Project Standard. You need a standard to assure consistent, coordinated CAD work.

If you are doing CAD work without a company standard, make developing such a standard your first priority.

When a company gets its first CAD system, it should adopt a CAD Standard ***before its people start making CAD drawings***. If a company just trains new CAD users and lets each of them invent their own standards, whatever they invent will almost certainly be incompatible with anything anyone else in the company is using (and also incompatible with the standards being used by clients and other project team members). By the time the company starts to work on CAD projects that involve multiple CAD users or exchanging CAD files with other project team members, each of its CAD users will be hip-deep in his own home-made system and will resent forcible attempts to change and follow someone else's system.

When the company gets that first CAD system, it should study the standards that are being used around it. The company should check:

- colleagues/competitors
- professional associations like the National Institute of Building Sciences and SMACNA (*see* Chapter 2)
- clients
- application software that includes a standard

These sources represent the environment in which the company will be doing its CAD work. What standards are they using?

Caution

Adopt a company CAD Standard that will let you work easily in your environment—a standard that will let you coordinate with your clients and other members of your project team.

A new CAD company should try to adopt a CAD Standard that is similar to those being used around it, particularly if there is a dominant standard in its geographic region or area of specialization. Given enough time, a company's own CAD staff may invent the perfect CAD Standard, one that fits its staff, its organization, its internal requirements better than anything else possibly could. This is no help, though, if the *perfect standard* is so idiosyncratic that it won't let the company communicate or exchange information with anyone else. (The company will also have to pay its staff for the time it spends developing this *perfect standard*.)

In developing your CAD Standard, make it your goal to design something that lets you work effectively, not just internally, but also with other members of the project team. If one standard is being used widely in your area by the people you will be teaming with—just adopt it (maybe with a few necessary internal variations) and save yourself a lot of effort, both in development time and in later coordination.

A.3.2 Layering Guidelines

These are covered in the CAD Specification portion of the CAD Standard. You can either develop your own CAD spec (and its included layering guidelines) or receive it as part of a project in which you are about to participate. Most likely, you will do both in succession—develop your own standards and then have them temporarily (you hope) supplanted by the standards required for your projects.

Caution

Implement general purpose or "standard" CAD Specifications thoughtfully. Don't let the fact that they offer an option for every possible situation tempt you into an overly-complex implementation.

Keep it simple. In implementing a general purpose CAD spec, use as few of its options as each project will allow.

Take a close look at the CAD specs you receive as you plan how to apply them to specific projects. Most general purpose CAD specs are far too long and contain far too many choices to be used as-is on any one project. The *CAD Layer Guidelines*, published and revised by the American Institute of Architects Press in 2001, will be longer than 40 pages. *The National CAD Standard* fills two thick volumes.

Neither of these guidelines necessarily contains more than they should—complex projects need complex data structures, and the developers of these guidelines meant for them to apply to complex projects and cover a wide range of situations. Therefore, the guidelines do contain more choices than are required for any specific project.

If some aspect of your project is relatively simple and straightforward, keep the structure of the CAD data for that project segment as simple as you can. Let's look at how this can work:

Example: SMACNA's CAD Standard lists four layers for diffusers:

M-HVAC-CDFF	HVAC ceiling diffusers
M-HVAC-ODFF	HVAC other diffusers
M-HVAC-RDFF	HVAC return air diffusers
M-HVAC-SDFF	HVAC supply air diffusers

If your project is complex, you may need to use every one of these layers. If your project only contains a few diffusers, though, consider putting them all into a single layer, M-HVAC-CDFF. Remember: your goal is to keep your project data structure as simple as is appropriate for your project.

A.3.3 Text Style and Size

These are also covered by NCS in the *Uniform Drawing Standard Drafting Conventions*. One bit of advice about text styles—use the fonts that come with your system wherever you can and avoid non-standard fonts. If you develop custom fonts or buy fonts from a third party and then incorporate them into your drawings, you may have trouble passing your data files to other team members. There are ways around these problems, but why complicate things unnecessarily?

Caution

Avoid fancy or custom text fonts. Keep it simple—stick with the standard fonts that come with your CAD system and you will avoid unnecessary coordination problems.

A.3.4 Library

Your company's CAD Standard should include provisions for developing a library. One of the most important ways you can improve your productivity with CAD is to let it help you avoid drawing things more than once. A library is the most obvious way to do this.

Caution

Develop a CAD library. It will improve your productivity and make your work more consistent.

Develop a basic library when you first get your system, then expand your library with every project.

Use your library.

Start your library with:

- Standard sheets with:
  - borders and title blocks
  - parameter settings for units, scales, text heights, etc.
  - layering schemes
- Standard symbols
- Standard details
- Standard data structures for typical project types
- Custom software—LISP routines, macros, user commands, etc.—that will automate repetitive tasks

Develop a second tier of information that includes files archived from your previous projects from which material might be re-used. When closing out a project, comb the files for material that should be added to your library.

Before drawing anything new for the current project, consult your library for guidance or for material that can be re-used, either as it is stored or with minor changes.

Make library development an ongoing effort in your company. Material for your library can come from many sources, including:

- specific library projects

- harvesting efforts conducted at the end of a project
- material from your suppliers and manufacturers
- material distributed at the beginning of a project

To maximize your benefit from library use, you must make a specific effort to: a) keep the library growing and up-to-date, b) keep it well organized and well documented, and c) make sure your CAD users are familiar with and actually use the library.

A.3.5 CAD and the Project Team

Different members of the project team will use their CAD systems and CAD drawing files in different ways and for different purposes.

A.3.5.1 Designer/Engineer

The project designer or engineer uses CAD for several purposes:

- to develop his own design information
- to run calculations when they are required for the design
- to prepare project contract documents
- to fulfill special owner requirements

In a "standard" project, the designer/engineer does most of his CAD work during the initial project design process and his CAD work is mostly complete before the contractors/subcontractors become involved in the project. Once he completes his work, the designer/engineer has CAD files that may be made available for contractors/subcontractors to use while preparing their own work.

The paragraph above said that the CAD files from the project designer/engineer "may be made available." This is not a sure thing and you cannot assume that it will happen.

Many designers/engineers are reluctant to pass their design files to a contractor/subcontractor. In the same way, you may be reluctant to pass your own design files back to the general contractor or on to the project owner. The reason for this reluctance is often a concern about liability for the contents of the files. For a more detailed discussion of these concerns, see ***Liability*** on page A.23.

The picture changes in a design/build project. In such projects, the team is assembled earlier in the project. In many cases, the principal project team members have already been identified when the design work begins and the contractors/subcontractors will work directly with the designer/engineer during design. The contractors/subcontractors may propose design ideas, help evaluate design and system options, and provide cost estimates for multiple options before final decisions are made.

Contractors/subcontractors may be asked to provide some project systems on a design/build basis, in which case they act as their own consulting engineers. Design of the overall project design and sub-systems must be carefully coordinated in such situations (to keep an air distribution system clear of structural members or light fixtures, or example).

Contractors/subcontractors may exchange drawing files with the designer/engineer before the design is complete. When this happens, it is critical to document all exchanges, to insure that all parties understand just what information is being exchanged and just what stage of completion the exchanged files represent.

When there are interim file exchanges, all parties must be particularly careful that everyone is working with the current version of the files and that all team members are updated when previous "current" versions are superseded.

The good news to report is that read only drawing file formats are growing in popularity as well as the inexpensive and frequently free file viewing software required to read them. Internet-based project collaboration service portals now offer unprecedented new opportunities to exchange information in a timely, responsible, and efficient manner. Test out these new technologies on smaller projects before committing them to larger projects where you have more at risk. Ask the tough questions about Internet security to safeguard your intellectual property. Explore the full scope of the cost of these services, so you do not experience any rude surprises as the size of your project document and drawing database grows. Admittedly, it is always important to proceed with caution into new arenas, however it may be equally important to avoid letting excessive caution prevent you from preceding to find out what these new technologies can do for you.

A.3.5.2 Contractor/Subcontractor

The sheet metal and air conditioning contractor/subcontractor cannot usually start work before receiving basic design information from the designer/engineer. This information may include a preliminary specification for the facility or the system the contractor/subcontractor is to provide. It may include a layout for the whole project that will show the contractor/subcontractor just where his installation must fit.

In manual drafting days, the contractor/subcontractor received this information as written specs or blueprints. Now that we have CAD systems, you may be able to get this information in an electronic format that will let you draw your own work right on top of the designer’s drawing file. This can save you significant time and effort. It can save you money and help you finish your drawings just that much sooner.

When you receive CAD files from other project team members, though, you must determine whether:

- the files reached you on schedule
- the files were prepared according to the Project CAD Specification
- the files contain the information you expected
- the files contain up-to-date information
- whoever provided the files warrants that the information contained in them is accurate

Once you receive information from the designer or the general and then do your own CAD work, you may have to pass your CAD files on to other parties. You may have to transfer your files to the general who may plan to use them himself in a project scheduling or project management system or may pass them on to the project owner. You may have to pass your files directly to the owner.

Caution

Understand your contractual relationships within the project team. Who do you have a contract with? Who has a contract with you? What do the contracts require?

Consider these relationships when you receive a request to deliver electronic files

If you do have a contract with someone who makes such a request, determine how the request fits into what the contract requires you to do.

If you do not have a contract with the requester, you may not be required to deliver anything.

If you are required to submit your CAD files at the end of your work, the files must be prepared according to the Project CAD Specification. If you pass your CAD files on to other project team members, be sure you completely document each submittal as described previously.

Don't send your CAD files to someone just because they asked for them. In doing so you may be voluntarily assuming liability that is not included in your contract. Deliver your CAD files only when you are required to do so by a contractual relationship or a legal requirement.

Understand your contractual relationships. Who is your contract with? What does your contract require you to deliver?

Suppose you are the air conditioning contractor and that your contract is with the general contractor.

What if the plumbing contractor asks for your CAD files? You do not have a contract with the plumbing contractor. You are not receiving any compensation for working with him. Anything you give him is a gift and by giving it you assume an undefined liability for the content of what you deliver. You are assuming liability that is not required by any written agreement and you are doing it for free! You have no contractual obligation to the plumbing contractor and you should not give him anything.

Suppose that in the situation above the general contractor asks you to deliver CAD files to a third party. You may not be required to make the requested deliver, but you want to be a responsible team member and keep the project moving forward. You will probably end up making the delivery as requested, but here are some suggestions:

- Determine whether your contract requires you to make the delivery.

- If the delivery is not required, consider requesting additional compensation. After all, you will be doing work that was not included in the original agreement.

- Deliver the requested material to the general contractor and let him pass it on to the third party. If you can't do this, deliver the material with a transmittal document which states that you are making the delivery at the general contractor's request.

- Document whatever you deliver. Pay special attention to describing what you deliver and its state of completion at the time of the delivery. Do not assume responsibility for updating the recipient on changes that occur after delivery.

A.3.5.3 Customer/Owner

The customer/owner may:

- provide CAD files to the project team at the beginning of the design process, or

- require that the project team deliver CAD files at the end of the project

At project start-up, the owner may provide files containing information about existing project conditions. This might include: site survey data, drawings of existing building conditions in the project area or existing adjacent structures, or drawings from previous project phases (preliminary designs, for example).

Caution

Will you be receiving electronic files from the project owner or other project team member?

Don't assume anything about how useful the files will be or how much time and money you will save by having these files.

Check these files carefully and determine how you will use them before you agree to a price or schedule for your work.

Owners usually provide this information to prevent the project team from having to gather the information themselves. Owners often expect that their providing these files will save work for their project team and, thus, reduce design fees. Sometimes this works out. Often it does not.

When you receive such files, you must verify a couple of things.

First, what is the condition of the electronic files?

- Are they well organized and were they executed carefully?
- Are they compatible with your CAD system and easy to read?
- Do they contain information you can use?
- Do they contain a lot of other information from which you will have to extract the useful parts?
- Does the value of the information contained in the files exceed what it will cost you to use them?

Second, is the information contained in the files accurate?

- Can you rely on the information without having to go to the field and verify it?
- Is the party who prepared the files available to answer your questions about them?
- Does the owner warrant the accuracy of the information? Few owners will make such assurances, but without such a warranty, you may have to field verify everything in the files. This makes the files much less valuable.

An owner may require you to deliver files at the end of the project for several reasons:

Project Archive. The owner may want to keep CAD files as a project archive. An electronic archive is more volatile than he may understand. Electronic files can become inaccessible and unusable through deterioration of magnetic media or through changes in hardware or software.

By the time the owner gets around to trying to use archived CAD files, he may find that he cannot read the files and may then start looking for the "responsible" parties. Your best protection is to educate the owner before the project starts. If you do not have direct access to the owner, you can only work through channels to spread this information.

Use in Later Project Phases. The owner may want to use the CAD files from your phase of the project to help implement later phases of the project (furniture and finishes or installation of equipment, for example).

A.3.6 Timing and Timing-Related Issues

CAD files may be exchanged many times during a project. With each exchange you must be aware of what is happening and you must ask yourself some questions.

Use in Facility Management. The owner may want to use the files to start a facility management system. In such situations, the owner may modify your files and go on to use them in ways you had never considered.

Caution

Your CAD files can be changed without a trace by anyone who has copies of them.

Protect yourself from liability for the problems of people who modify your files and then use them inappropriately.

Include appropriate language in your agreements and in transmittals.

You must protect yourself from liability for problems arising from use of modified versions of your files. Make sure your contract language provides such protection. Also, keep careful documentation of your submittals (both electronic files and hard copies) so that in case a problem should arise, you will be able to determined just what was included in the files when you delivered them.

A.3.6.1 Pre-Project

This occurs before any project work starts, or, if you are a sub-contractor, before your part of the project work begins. Pre-project CAD data exchanges typically consist of files you receive from the owner or the general contractor that contain (or are supposed to contain) information you will need to do your work.

In working with such data exchanges, you must determine:

- ***When will you receive the files?*** Exactly when are you supposed to receive the files? Who is responsible for providing them (get the name of a specific person)? If the files are not delivered when scheduled, will you get more time (or money) to complete your work?

- ***Who made the files you will receive?*** Was it the owner, the designer, the general contractor … or maybe a third party who is not on the project team? Is there anyone you can contact with your questions about the files … or are you on your own when it comes to using them?

- ***What do the files contain?*** Do they contain the information you need? Do they contain a lot of other information that you can't use? How much work will it require to separate the useful material from the parts you can't use?

- ***How were the files made?*** What was the CAD specification? Was it followed carefully … or will you have to do a lot of editing to get the information you need organized so you can use it conveniently?

- ***What is the quality of the files?*** Are they complete? Are they correct? Will you have to field verify any of the information?

A.3.6.2 During the Project

While the project work is going on, there are typically two kinds of CAD file exchanges:

- passing files back and forth with other members of the project team for coordination purposes

- making required progress submittals to the project owner or the general contractor

In considering such exchanges, determine:

- ***Project CAD Specification.*** What is the CAD specification for the files to be exchanged? Do you plan to follow your own internal CAD Standard and later translate your CAD files to meet the CAD spec? How much effort will it take for you to make this translation?

- ***Exchange Schedule***. How many CAD files exchanges will you make? (How many are required in your contract?) When will you make the exchanges? (Remember that each exchange will take time and money.)

- ***Exchange Contents.*** What information will each exchange include? Which drawings will be included? What will be shown on each drawing? What stage of completion does each exchange represent? How can you use the files you receive?

- ***Documentation***. How will you document these exchanges to track: what you deliver, what you receive, when exchanges are made, etc.?

- ***Version Control.*** How will you assure that other team members are using the most recent version of your work —and how will they know if they don't have the most current version? How will you know that you have the most current version of files from other team members?

- **Acceptance.** This issue arises in the case of progress submittals when the project team submits preliminary data to the project owner or perhaps construction manager. In these situations, the party receiving the submittal is supposed to review it in a timely manner and notify the project team of any exceptions taken to the preliminary design. On receiving this notification, the project team members can make required changes and proceed with their work. How can you be sure review and acceptance will be timely? How can you protect yourself from being forced by deadline pressures to proceed with your work before receiving the necessary approval? See **Liability** on page A.23 for more discussion.

- ***Ownership.*** Who will own the electronic files that you deliver to others? In the case of coordination files exchanged with other project team members, this is not a significant issue. It is an issue when design files are passed to the project owner or end user. See the discussion of this issue in the next section.

A.3.6.3 Post Project

These data exchanges are made when everyone’s work is complete and final project documents are prepared. These exchanges usually involve having project team members pass their files on to the general contractor and then to the project owner for the owner’s ultimate use.

In making such exchanges, determine.

- ***Project CAD Specification***. What is the CAD specification for the files you will submit?

- ***Submittal Contents.*** What specific information are you required to submit?

- ***Acceptance***. At what point is the recipient deemed to have reviewed and accepted the files? When are you relieved of responsibility for the content of the electronic files? After all, electronic files deteriorate over time and they can be modified without a trace. At some point the recipient must assume responsibility for maintaining the files and safeguarding their contents. See ***Liability*** on page A.23 for further information.

- ***File Ownership***. Who will own the electronic files you deliver to others? This becomes an important issue with the files that the project owner or end-user receives. Ownership will determine which party can use the information contained in the files and how the files can be used. The electronic files of your CAD drawings are a database that is potentially much more valuable to the owner or end-user than your paper drawings ever were, so don’t rush to give them away without compensation. Depending on the specifics of your contract, you can retain ownership of your files, transfer ownership to the owner or end-user, or establish a shared ownership of the files.

This may be the time to meet with the client or end-user to determine just how he plans to use your files and then discuss how you might work with the files and provide additional services.

- ***The Receiver.*** Who will ultimately receive your submittal—the general contractor, the project owner, the end user, or consultant for a later phase of the work? How will this party use your files? Is this an appropriate use for your files? If not, how can you protect yourself?

- ***Archiving Issues***. Does the project owner plan to keep your files as an archive? Does he understand the limitations of electronic archives? What should you keep for your own archive?

A.3.7 Data Exchange

Project have become increasingly sophisticated in recent years. Today’s project team includes many members, many more than were involved just a few years ago. A typical project team might include: designers and their design consultants, contractors and subcontractors, manufacturers and suppliers, and the project owner and end users.

Project team members work together in a complex matrix of relationships which changes as the project moves from preliminary phases through the end of construction and user occupancy.

Project information flows through this matrix. At any time some project team members may want project information another member has or is developing. At any time you may have information that another team member will want.

Before automation, much project information was passed back and forth between project team members. Automation and CAD systems particularly have made it even easier to pass information back and forth among project team members and to do it quickly.

The free, rapid flow of information among project team members can help team members communicate quickly, and can save time and effort as team members have the information they need instead of having to wait for it, and can keep the project moving forward.

The uncontrolled flow of project information among project team members can also pose risks. Without proper control, team members can end up:

- working with data that is incorrect, not ready, unchecked, or for other reasons should not have been exchanged
- working with data that represents a design alternative rather than the actual design
- working with design information that has not been approved for release
- working with outdated information
- working with multigenerational copies of data files
- not knowing whether changes were made to the files as these copies were madeInformal information exchanges among project team members can lead to these problems and raise serious liability problems.

In a well-run project, data exchanges between the team members are established in the contracts and are then managed carefully. The manager may be the principal designer, the general contractor, the construction manager, or some other party. The data exchange manager's role may even pass from one party to another as the project moves from one phase to the next.

Without effective management of data exchange within the project team, each team member is on his own. Careful team members will implement their own data exchange management systems and there will be a great deal of duplicated effort.

Whether project data exchanges are well managed or not, each project team member must protect himself. His goals should be:

- to use CAD files received from others only if he can verify that they contain correct and current information
- to assure that the information he is using from outside sources is kept current as changes occur
- to assure that he releases only correct and current data to other team members
- to document the whole process and develop a paper trail in case of later questions

These principles apply when you are working on a multi-member project team. They also apply when you are just working with other teams or even just other individuals in your own company.

When working on a multi-member project team, your first step is to determine the nature and structure of your contractual relationships.

Don't give your CAD files (or other project documents) to anyone with whom you do not have a contractual or a legal obligation (such as fire marshals and others with review authority). This caution applies to other project team members, of course, but it also applies particularly to outsiders who want the information for their own uses. Let the general contractor or the project owner handle these requests.

Don't deliver CAD files unless the contract requires that you deliver them. If you are a sub-contractor to the general and you need to exchange CAD files with another sub, make the exchange through the general.

Caution

When you exchange electronic files documentation is critical.

Document everything that you receive and everything that you give to anyone else.

Documentation can help you re-construct events after the fact if questions arise. More immediately, though, documentation can help you and your project team to keep track of where things stand on a day-to-day basis.

Let the general (or designated data exchange manager) manage these issues. Let the general keep track of who has received what, when the delivery occurred, percentage completion at the time of the exchange, etc. Let the general act as the data coordinator and traffic cop for the project.

Assume, then, that you have settled these contractual issues and are preparing to exchange CAD files with other members of the project team.

Before you pass CAD data files to another project team member:

- ***Determine what you are delivering***. What files are included? Which drawings do they include? What were the design assumptions under which the drawings were made? What is the currency date of the material you are delivering? How complete are the drawings at the time of the exchange.
- ***Be sure you deliver only what you intend to deliver.*** Check your files before you send them. Check all the layers/levels and make certain they do not include material that you do not want to send—such as proprietary material, private notes, etc. If you only want to deliver part of a file's contents, write a new file that contains only what you want to send. This simple precaution can save you embarrassment.
- ***Document your delivery carefully.*** Keep a copy of your transmittal and other documents describing exactly what is being delivered. Keep hard copies of the drawings included in the CAD files. Keep copies of the CAD files. Keep a record of who is receiving the delivery and of your relationship with this party (establish why you are making the delivery). List any third parties who you know will be receiving copies or your delivery.
- ***Update recipients***. Understand that you will want to keep the recipient updated on any changes (the project data coordinator may be responsible for seeing that this happens, but don't just assume that it will occur).

Whenever you receive CAD data files from another project team member:

- ***Determine what you have received.*** What files are included? Which drawings do they include? What were the design assumptions under which the drawings were made? How complete are the drawings at the time of the exchange. Who made the files you have received—the sender, or another party? Much of this may be indicated on the sender's transmittal, but you should verify it anyway.
- ***Document it carefully.*** Keep the sender's transmittal and any related correspondence. Keep any notes that you make during your confirmation of the delivery. Keep a copy of the files as you received them in your project records.
- ***Commit to updating.*** Understand that you must keep yourself updated on any changes to the information.

A.4 LIABILITY

In discussing liability issues, a useful starting point is the assumption that each project team member should be responsible for his own work. This principle would be very helpful if each team member could work independently, never interacting with other team members, and just submit his finished work at the end of the project.

Unfortunately, this is not the case, nor has it ever been the case except in the very smallest and least complex projects.

A typical project in today's environment includes several participants who are separate entities and organizations which must work together as a team. The success of any one team member depends on the other team members doing their jobs correctly: before he begins work, while he is working, and after his work is finished.

In this kind of team model, the team members must work cooperatively and interdependently throughout the life of the project. They must pass a great deal of information (CAD files and many other things) back and forth during the project and they must be able to rely on the information they receive and stand behind the information they pass to others.

This complicates the liability picture.

It is possible to develop a workable liability structure from the complex matrix of relationships that constitutes today's typical project. Steps toward such a liability structure include:

- project contracts that describe data exchanges between project members
- who will provide information and who will receive it?
- how many exchanges will be made?
- what will be included in each exchange?
- what is the state of data currency at each exchange?
- what is the furnisher's responsibility for the data provided?
- how can the data be used once it is received?
- a structure to manage the day-to-day details of data exchange
- tracking scheduled data exchanges
- assuring that exchanges are made as scheduled
- receiving CAD files from the parties who are supposed to provide them
- verifying that the files contain the information they are supposed to contain
- conveying the files to the parties scheduled to receive them
- assuring that the parties who receive CAD files are kept current as changes are made to the files

Establishing and operating this kind of structure requires a significant effort and additional costs—initially. The effort pays off quickly in terms of improved data flow, reduced confusion, and clear liability.

If this structure is established on a project-wide basis and if team members feel confident it will work smoothly, a savings will be achieved by reducing duplicated efforts among team members as each tries to cover his own liability exposure.

The overall goals of such an organization must include:

- A successful project in which the work runs smoothly and without delays, everyone makes a fair profit, and at project's end everyone involved (including the project owner) feels good about everyone else on the team and looks forward to working with them again.
- A free and open exchange of information among the project team members. Such an exchange means that each party receives from other project team members the information he needs to perform his own work. It also means that each party must provide information about his own work to other parties need for their work.
- An equitable and appropriate distribution of liability among the members of the project team.

A.5 CONCLUSION, SUMMARY, AND RECOMMENDATIONS

CAD systems offer many potential benefits to SMACNA members.

The most obvious benefits are using CAD in-house to produce your own drawings. Select a good CAD system and adopt an in-house project CAD standard similar to those used by your colleagues and you can experience significant gains in productivity as you produce your drawings, perform design calculations, generate quantity take-offs, etc.

You can benefit further from CAD use when you receive CAD files from other project team members. Using this information, you can:

- get drawings of existing site conditions in CAD format (rather than having to gather the information and draw it up yourself)
- learn about the design intentions of other team members
- perform ongoing coordination between your work and that of other team members

In achieving this second tier of benefits, though, you will encounter challenges in the areas of data coordination, additional costs, and liability.

These challenges are best addressed by project-wide efforts that begin with the general contractor or the project owner. Lacking such efforts, you must take whatever steps you can to protect yourself (and so must all the other team members).

The considerations above relate primarily to automating projects as they are currently performed.

Creatively used, your CAD system can become a tool that will be useful in other ways, too.

CAD work can be a way for you to make yourself known to the project owner. Using modern technological tools effectively to produce successful work can let you stand out on the project team and keep you from getting lost among all the other sub-contractors.

Your CAD system can be a great sales tool. CAD includes tools that will let you present your work to your clients in forms they can readily understand. A 3D model or a process flow simulation can help your client understand your design with much greater clarity than you could achieve with 2D mechanical design drawings, performance charts, or verbal descriptions. Your sales efforts will be much more effective when you can communicate your proposal clearly, when you can really show it to your client.

Your CAD system will let you offer new products and services that extend beyond the construction of the project. As you use your CAD system to develop your project design, you build an electronic database that describes the facility and your design. If developed carefully, this database is a product that has great potential value to your client.

You can add non-graphic data (attaching to the graphic representation of a piece of equipment information such as: manufacturer name, model number, serial number, installation date, maintenance recommendations, etc.) and offer your client a set of electronic files that will connect directly into his facility management system. Such a system can help a client manage system maintenance activities, assure inventory of belts and filters, or even issue preventive maintenance work orders. You can even use the database yourself and offer to monitor and maintain the client's facility yourself.

All in all, CAD can be a valuable tool for the SMACNA member. Like any other new and powerful tool, though, you must use it with planning and care.

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APPENDIX B

CAD PROJECT SPECIFICATION CHECK LIST

System Elements

- **Hardware Definition**
  - Does the Project CAD Specification require that you use a specific computer hardware platform? For example, **IBM PC-compatible.**
  - Does your computer hardware meet the requirement?
  - Is your computer hardware compatible with the requirement?
- **Operating System**
  - Does the Project CAD Specification specify the name and version number of the native operating system of the files you will receive? For example, **Microsoft Windows 2000**.
  - Does it specify the name and version number of the operating system under which the files you deliver will be read?
  - Can your system work with this requirement?
- **CAD software**
  - Does the CAD specification specify the name and version number of required CAD software? For example, **AutoCAD 2000**.
  - Do you have the required CAD software?
  - If not, will your CAD software let you deliver files that are compatible with the required format? (Think about this carefully. Make tests to verify this compatibility before you sign an agreement.)
- **Other software**
  - Does the CAD specification require you to use any other software such as design calculation software?
  - Can you meet this requirement?
- **Delivery Medium**
  - Does the CAD specification require you to receive or deliver electronic files on a specific medium. For example, **3 ½" floppy disks, Iomega ZIP disk, electronic mail, or an Internet project collaboration portal**.
  - Can you meet this requirement?

Design Elements. Does the Project CAD Specification establish standards and requirements for:

- **Directory and file structure**. How must your data directories and files be organized?
- **Drawing names and descriptions**. What drawings are you required to produce? What must they be named? What information must they include?
- **Reference file structure**. What reference files must be attached to design files, and how must they be organized?
- **Saved views/windows**. Are there requirements for saved views that will include only portions of drawing files? (These might specify several saved views of a drawing which each have different layers turned on or off. They might also specify views that include specific portions of a larger drawing.)

- **Layering/leveling conventions**. How must the drawing information be divided into layers? What information goes into which layer? What is the name/number of each layer?

- **Entity naming conventions**. What names must you use for: assemblies, blocks, cells, details, symbols, etc.?

- **Line types, weights, and colors**. What line types, weights, and colors must you use? In what circumstances are you required to use them?

- **Text fonts and sizes**. What line text fonts and sizes must you use? In what circumstances are you required to use them?

- **Symbols and other library materials**. What library materials must you use? How are you required to use them?

- **Drafting Standards**. What are drafting standards for the project?

Procedures. What are the established procedures for handling the project CAD work?

- **Number of and schedule for submittals**. How many electronic file submittals are you required to make? When must you make them?

- **Require submittal contents**. What must be included in each submittal?

- **Procedure for each submittal**. How must each submittal be made? Do procedures vary between submittals?

- **Review and acceptance procedures**. How will your submittals be reviewed and accepted? (Will they be reviewed and approved in a timely manner? … or will you have to proceed with the remaining work without approval?)

APPENDIX C

THE CAD PROJECT CHECK LIST

This checklist does not contain all the answers. This would be impossible. Instead, the list aims to offer some specific guidelines, and also describe the questions you should ask through the life of a project.

Once you consider these questions and determine the answers, you can make decisions about the project. You can decide:

- whether you want to pursue the project at all
- whether the project material includes all the information you need
- whether you should request more information
- whether you should ask for more time or money to meet some project requirements

PRE-PROJECT

- **The Contract**
  - Who will your contract be with? … the project owner? … a general contractor? … a construction manager? … someone else?
  - Have you worked with this party before?
    - If so, was the previous project successful?
    - If not, can you learn anything about the party?
  - Have other team members been identified? Who are they?
- **The CAD Requirement**
  - Why is CAD use required?
    - Where does the CAD Requirement come from? … the project owner? … the contractor or construction manager? … the project end-user?
    - Who will receive the CAD files? Will all deliveries go to the same party, or will they be split?
    - How will these parties use the CAD files?
    - Are these appropriate uses for the files? Can the files really be used in the way the recipient plans?
    - Is the party that requires the files CAD-knowledgeable? … or will you have to spend time educating him?
  - Hardware and software requirements
    - Can you meet the requirements with your current system?
    - Will you have to buy anything else?
    - Will you have to go through a learning curve with the new items?
    - What will it cost to implement these changes?

- The Project CAD Specification
    - Is there a Project CAD Specification, or will you have to work with the owner, contractor, etc. to develop one? (and what will this effort cost?)
    - How different is the Project CAD Specification from the CAD spec you normally use in your practice?
    - Will you be required to translate CAD files to meet the spec?
    - Will you be able to test the file exchanges before you must make a submittal?
    - What will this effort cost and how long will it take?
- The Project CAD Standard
    - What parts of your work are you required to prepare with CAD?
    - What CAD materials will you receive from other project team members?
    - How will the material reach you? … and who will be responsible if you don't receive it as promised?
    - Who produced the material? … and is anyone available to answer your questions about the material?
    - Material content: does it contain the information you want? …is it all there? … is other information mixed in with the information you need? … will it be hard to separate out the information you need?
    - Material organization: to what CAD specification was the material prepared? … was it followed closely?
    - Material quality: does anyone certify that the material contains correct information? …will you have to field verify any of the information? … what will the field work cost?
    - Can you test samples of this material before you sign a contract?
    - What will it cost you to use this material? … Will using it really save you anything or will it just complicate things?
    - What CAD data must you submit?
    - What are the required submittals and when must they be made?
    - What must be included in each submittal: which drawings? … what information must be included on each drawing? … what is the required degree of completion? -- answer these questions for each submittal.
    - Is it likely you will have to make unscheduled submittals?
    - What will it cost you to make the submittals (beyond the cost of just doing the CAD work)?
    - Will the general contractor or some other party adequately manage the CAD data during the project as it passes among project team members? … or will you have to spend time managing this yourself?

DURING THE PROJECT

- **File Exchanges**
    - What electronic files will you receive during the execution of the project?
    - What electronic files are you required to deliver during the execution of the project?
- **Documentation**
    - Document all the CAD files that you receive from others in the project team.
    - Document all the files you deliver to other team members and third parties.
    - Documentation must include:
        - the date of the exchange
        - the party received from (or delivered to)
        - the reason for the exchange
        - identification of the files exchanged
        - identification of the drawings included
        - identification of the contents of each drawing
        - identification of the state of completion of each drawing at the time of the exchange.
        - electronic files and hard copies of the drawings
- **Liability**. Limit your liability for the electronic files you pass to others by:
    - establishing how your files are intended to be used
    - using hold-harmless language to protect yourself from liability for use of your files for unintended purposes or for use of files that have been modified
    - clearly establishing in your documentation which of the files you pass to others are finished and which are preliminary, incomplete, or unfinished
- **Currency**
    - Verify that the electronic files you receive are current as of the time you receive them or as of some date/time indicated in the documentation.
    - Indicate a currency date/time in the transmittal documentation that accompanies any files you pass to others.
- **Update**
    - Before completing your work, verify that any information you have received from other parties has been updated and is current.

    - As you complete your own work, try to assure that the parties who received your electronic files in interim submittals have received updates and are using current information.

POST-PROJECT

- **Submittals**
    - What electronic files and which drawings are you required to submit at the end of the project?
        - Design drawings?
        - Construction drawings?
        - Record drawings? If yes, does your fee include updating the drawings during construction?
        - Drawings especially designed to fit into a facility management program or other end-user system?
    - What is the required format for these files? Is it the same as that for the interim submittals?
    - What is the procedure for the owner accepting your electronic files?
    - Who will own your electronic files after you submit them?
    - What archiving activity will you have to perform at the end of the project?
        - What archives does the contract require you to maintain? (avoid such requirements if you can)
        - What archives will you want to maintain for your own uses?

APPENDIX D

TRANSMITTAL LETTER

The following is a sample letter of transmittal to accompany CAD file deliveries. This transmittal letter is intended to:

- establish disclaimers limiting the compatibility of the files to a specific hardware and software system
- establish an acceptance period for the recipient to review and accept the electronic files (and then accept responsibility for maintaining them)
- hold the writer harmless from liability for misuse of the files or use of file copies that have been modified
- establish precedence of the sealed hard copy of each drawing over the corresponding electronic file

The letter requests that the recipient endorse a copy of the letter and prints of the drawings and return these to the writer.

This letter is probably not appropriate for use with file exchanges among design team members for coordination purposes, but it or something like it should be used at the end of the project when final sets of files are delivered to the owner or end user.

The sample transmittal letter printed here is intended for use in situations where the party receiving the files will also receive ownership of the files and the drawings. The letter should be somewhat different if the designer/contractor is to retain drawing and file ownership or if ownership is to be shared.

Dear **CLIENT NAME**:

The enclosed **DESCRIBE MEDIA** contains the CAD files created for **PROJECT NAME**. These files are being delivered to you per our agreement dated **DATE**. The files contain **DESCRIBE FILE CONTENTS**. Also enclosed are two complete sets of blue-line copies of the plotted CAD files.

The submitted data files are intended to work only as described in the agreement. These files are compatible only with **DESCRIBE CAD SYSTEM** (example: AutoCAD 2000, operating on an IBM-compatible PC using Windows 2000). **FIRM NAME** makes no representation as to the compatibility of these files beyond the specified release of the above-stated software. **CLIENT NAME** agrees to save and hold **FIRM NAME** harmless for uses of the file data outside of or beyond the scope of this agreement.

Because data stored on electronic media can deteriorate undetected or be modified without **FIRM NAME**'s knowledge, **CLIENT NAME** agrees that it will accept responsibility for the completeness, correctness, or readability of the electronic media after an acceptance period of 30 days after delivery of the electronic files, and that upon the expiration of this acceptance period, **CLIENT NAME** will indemnify and save harmless the **FIRM NAME** for any and all claims, losses, costs, damages, awards or judgments arising from use of the electronic media files or output generated from them. **FIRM NAME** agrees that it is responsible for the accuracy of the sealed drawings that accompany the submittal, and that such accuracy is defined as the care and skill ordinarily used by members of the consultant's profession practicing under similar conditions at the same time and in the same locality.

The electronic files are submitted to **CLIENT NAME** for a 30-day acceptance period. During this period, **CLIENT NAME** may review and examine these files and any errors detected during this time will be corrected by the **FIRM NAME** as part of the basic agreement. Any changes requested after the acceptance period will be considered additional services to be performed on a time and materials basis, at **FIRM NAME**'s standard cost plus terms and conditions.

The **CLIENT NAME** shall be permitted to retain copies of the drawings and specifications prepared in CAD format for the **CLIENT NAME**'s information in their use of the project. Due to the potential that the information set forth on the computer disks and/or magnetic tapes can be modified by the owner, unintentionally or otherwise, the **FIRM NAME** reserves the right to remove all indicia of its ownership and/or involvement from each electronic display.

Any use or reuse of altered files by **CLIENT NAME** or others, without written verification or CAD adaptations by **FIRM NAME** for the specific purpose intended, will be at **CLIENT NAME**'s risk and full legal responsibility. Furthermore, **CLIENT NAME** will, to the fullest extent permitted by law, indemnify and hold **FIRM NAME** harmless from any and all claims, suits, liability, demands, judgments, or costs arising out of or resulting from any use of these files.

CLIENT NAME is hereby requested to review the contents of the CAD files and compare the contents of the CAD files to the two sets of copies of the plotted CAD files. If the CAD files are in agreement with the copies of the plotted CAD files submitted, please so acknowledge this by signing this letter below and both sets of the copies of the plotted CAD files, and return this letter and one set of copies of the plotted CAD files to **FIRM NAME** within the 30-day acceptance period indicated above. If the CAD files do not agree with the copies of the plotted CAD files, please inform **FIRM NAME** as soon as possible.

Failure to sign and return this letter and one set of contract drawings within the 30-day acceptance period, **FIRM NAME** will assume that **CLIENT NAME** will have accepted the CAD files as being within conformance of the agreement between **CLIENT NAME** and **FIRM NAME**.

FIRM NAME will not make any attempt, nor will **CLIENT NAME** hold **FIRM NAME** responsible, to maintain the completeness, correctness, or readability of CAD files after the acceptance period described above.

If, at anytime, there exist a difference between the submitted CAD files and the original sealed mylars, the sealed mylars will govern as the official delivered contract drawings.

Sincerely,

FIRM NAME

SHEET METAL AND AIR CONDITIONING CONTRACTORS'
NATIONAL ASSOCIATION, INC.