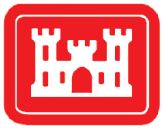
ERDC/ITL TR-12-1



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A/E/C Graphics Standard

Release 2.0 (formerly titled CAD Drafting Standard)

Stephen C. Spangler

August 2015

Information Technology Laboratory

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Stephen C. Spangler

The CAD/BIM Technology Center
Information Technology Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, Mississippi 39180-6199

Release 2.0

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000

Abstract

The *A/E/C Graphics Standard* has been developed by the CAD/BIM Technology Center to document how proper hand-drafting practices can be achieved in Building Information Modeling (BIM), Civil Information Modeling (CIM), and Computer-Aided Design (CAD). It is through the collection and documentation of these practices that consistent models and drawings shall be achieved throughout the U.S. Army Corps of Engineers (USACE), as well as other federal agencies. In the collection of these practices, various historical USACE District drafting manuals were consulted and compared against practices contained in various industry and national standards. The documentation of these practices will help to achieve both clear and aesthetically pleasing construction documents.

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Preface

Introduction

The *A/E/C Graphics Standard* has been developed by the CAD/BIM Technology Center (hereafter referred to as the Center) for Facilities, Infrastructure, and Environment at the Information Technology Laboratory (ITL), U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS. Its purpose is to address a need for standard BIM, CIM, and CAD drafting practices that were once covered by documents related to hand drafting techniques. This report supersedes *CAD Drafting Standard* (ERDC/ITL TR-12-1).

The Center acknowledges the support of Jason Fairchild, Headquarters, U.S. Army Corps of Engineers (HQUSACE). Special thanks go to the following USACE people for their technical expertise in the development and review of this document: Roger Fujan, U.S. Army Engineer District, Omaha; Carl Broyles, U.S. Army Engineer District, Kansas City; Michael Brennan, U.S. Army Engineer District, New Orleans; and Gerald Piotrowski, U.S. Army Engineer District, Louisville.

At the time of publication of this report, the Director of ITL was Dr. Reed L. Mosher, the Deputy Director was Patti Duett, the Chief of the Software Engineering and Informatics Division was Ken Pathak, and the Chief of the CAD/BIM Technology Center was Edward L. Huell. The Director of ERDC was Dr. Jeffery P. Holland, and the Acting Commander of ERDC was LTC John T. Tucker III.

United States National CAD Standard®

In 1995, the combined resources of the Center, the American Institute of Architects (AIA), the Construction Specifications Institute (CSI), the United States Coast Guard, the Sheet Metal and Air Conditioning Contractors National Association (SMACNA), the General Services Administration (GSA), and the National Institute of Building Sciences (NIBS) Facility Information Council began an effort to develop a single CAD standard for the United States. Working together, these organizations agreed to develop an integrated set of documents that collectively would represent the United States National CAD Standard (NCS).

The primary NCS document referenced within the *A/E/C Graphics Standard* is the following:

"Uniform Drawing System"
The Construction Specifications Institute
99 Canal Center Plaza
Alexandria, VA 22314-1588

This document is available as part of the NCS to all USACE personnel through an enterprise license with NIBS. Additional information on the NCS can be obtained from the following:

National Institute of Building Sciences
1090 Vermont Avenue NW, Suite 700
Washington, DC 20005-4905
http://www.nibs.org/

1 Introduction

1.1 Acronyms

First, a few useful acronyms:

- A/E/C – Architecture, Engineering, and Construction
- BIM – Building Information Modeling
- CAD – Computer-Aided Design
- CIM – Civil Information Modeling
- CSI – Construction Specifications Institute
- NCS – United States National CAD Standard
- NIBS – National Institute of Building Sciences
- UDS – Uniform Drawing System
- USACE – U.S. Army Corps of Engineers

1.2 Background

The *A/E/C CAD Standard* (CAD/BIM Technology Center 2015), first published in May 1994, has been the go-to manual for developing CAD documents for tri-service A/E/C disciplines. The Standard defines symbology, graphic representations, and layer breakouts within the different types of CAD files the A/E/C disciplines typically create.

However, what it does not cover are the good practices behind CAD drafting. These practices were required learning for all new architects, engineers, and draftsmen when hand drafting was the only way of creating construction documents. With the incorporation of CAD into design, these practices were lost along the way. The USACE CAD Community of Practice (formerly the Field Action CAD (FAC) Committee) recognized this fact and tasked the Center to develop a manual *reintroducing* these practices, however, updating them to fit into the CAD workflow.

In the development of this manual, the Center collected many District drafting standards, compared them, and compiled similarities. Where applicable, the practices pulled from these drafting standards were compared with those of industry and national standards, since those documents address drafting to a certain extent. In situations where industry and national standards did not make a strong statement as to a

drafting methodology, the USACE drafting standards were considered to be the expert opinion and took priority in decisions.

1.3 Essentials of good drafting

Why bother with developing a manual that addresses drafting practices? The *A/E/C CAD Standard* already implements practices in the formation and presentation of final CAD files; isn't that enough? The U.S. Army Engineer District, Jacksonville, Drafting Standards manual dated September 1976 (U.S. Army Engineer District, Jacksonville 1976) probably states the reason best in a section called "Essentials of Good Drafting":

> A well prepared drawing, complete so that it conveys the intended meaning yet contains a minimum of unnecessary detail, is the type of drawing which is required. Such a drawing, when [correctly] prepared, reflects credit to the [engineer, architect], or draftsman who was responsible for it. While the principal object in working up drawings is to produce a neat, accurate set of plans in the shortest possible time, it is not the intention to sacrifice neatness and accuracy for speed or vice versa. When making alterations or additions to existing drawings, special care shall be exercised to follow the same style and size of lettering and all other conventions on the drawings for uniformity.

In addition to this reason, agencies should constantly strive for a sense of consistency. This results in a feeling of a more unified workplace as all architects, engineers, drafters, and partners are following a consistent set of rules and guidelines.

1.4 Additions/revisions

This graphics standard is intended to be neither static nor all inclusive and thus will be updated and enhanced as appropriate. Suggestions for improvements are strongly encouraged so that subsequent updates will reflect the input and needs of CAD users.

Recommendations or suggested additions should be sent to CADBIM@usace.army.mil.

2 Border/Cover Sheets

Note: *In an effort to make sheets more consistent across all agencies, the only borders/cover sheets that shall be used are those defined in this section. This supersedes all previous border definitions from all other various locations. The border and cover sheet files can be found on the Center's website:* https://cadbim.usace.army.mil/.

2.1 Border Sheets

2.1.1 Sheet sizes

A/E/C projects (contract documents) shall be prepared on ANSI D sheets (ANSI E or F may be used for large maps [e.g., installation master plans and drawings for civil works projects]). For international projects, ISO A1 sheets are to be used (ISO A0 may be used for large maps). Table 2-1 lists the standard sizes of ANSI and ISO sheets.

Table 2-1. ANSI and ISO sheet size comparison.

ANSI and ISO Sheet Size Comparison			
ANSI		ISO	
Mark	Size in inches	Mark	Size in inches (mm)
F	28.0 x 40.0	NA	NA
E	34.0 x 44.0	A0	33.1 x 46.8 (841 x 1189 mm)
D	22.0 x 34.0	A1	23.4 x 33.1 (594 x 841 mm)
C	17.0 x 22.0	A2	16.5 x 23.4 (420 x 594 mm)
B	11.0 x 17.0	A3	11.7 x 16.5 (297 x 420 mm)
A	8.5 x 11.0	A4	8.3 x 11.7 (210 x 297 mm)

Note: *The CAD/BIM Technology Center provides only ANSI A, B, D, E, and F-size border sheets on its website. For those agencies requiring ANSI C-size or ISO sheets, those sheets are to be developed internally, following the guidelines set in this section.*

2.1.2 Sheet margins

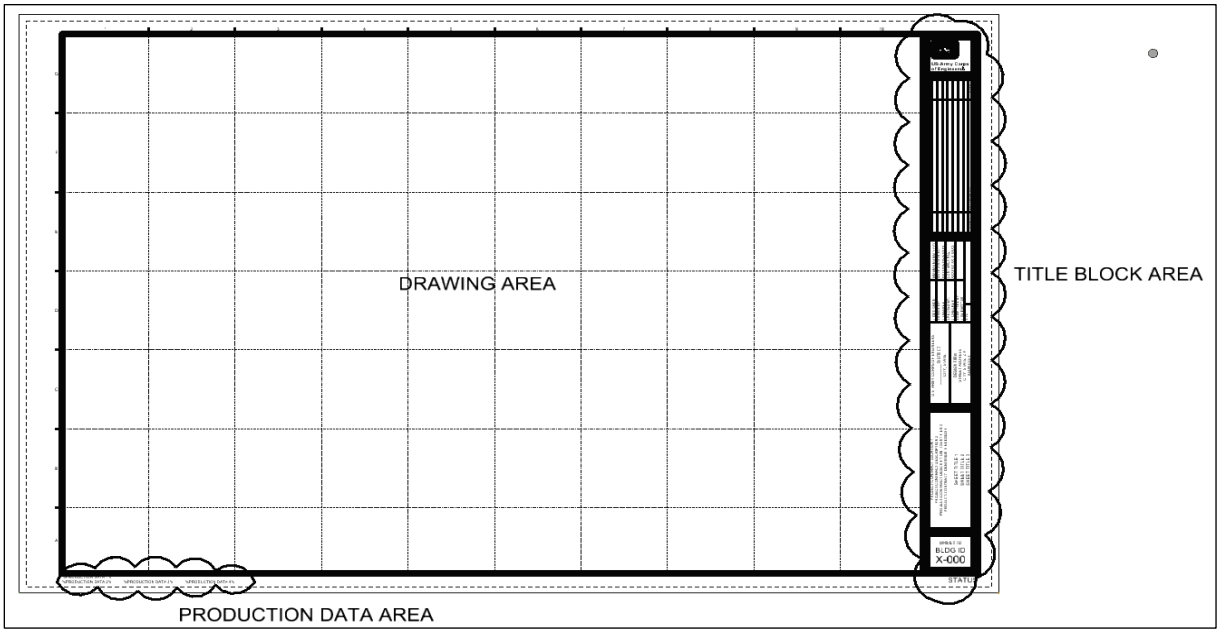
To develop the graphics for the sheet border, the following minimum sheet margin guidelines shall be used:

- top, right, and bottom margin: 3/4 inch (in.) (20 millimeter [mm])
- left margin: 1-1/2 in. (40 mm).

2.1.3 Border sheet areas

The border sheet is broken out into three main areas. These areas are the Production Data Area, the Drawing Area, and the Title Block Area (Figure 2-1). Of these three areas, only the Production Data Area is optional.

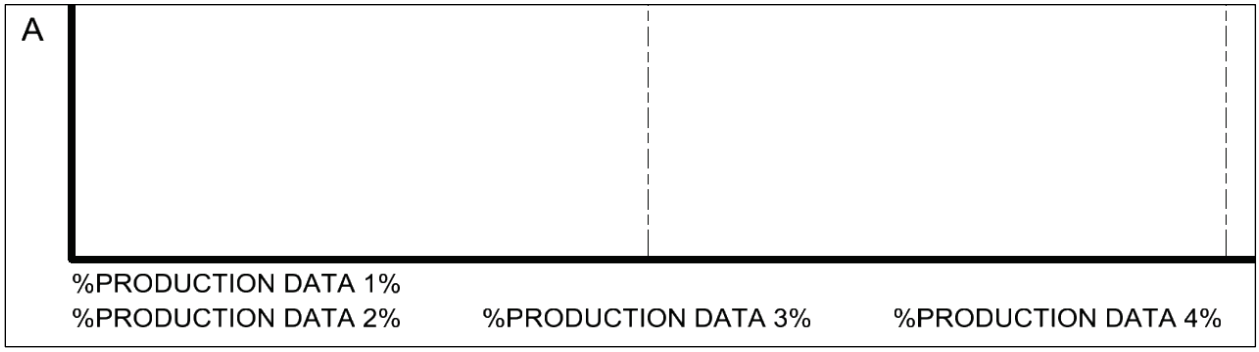
Figure 2-1. Three main areas of the border sheet.



2.1.4 Production Data Area

The Production Data Area contains detailed production information about the sheet. The information is located outside of the Drawing Area border in the lower left corner of the sheet (Figure 2-2).

Figure 2-2. Production Data Area.



As mentioned, use of this area is optional. Examples of information that could be provided in the Production Data Area include

- full path and file name
- date/time the sheet was plotted
- name of the user who plotted the sheet
- plot scale of the sheet.

Note: *The default text is commented with percent signs (%) to allow for text substitution via design scripts, pen tables, or attributes/tags.*

2.1.5 Drawing Area

The Drawing Area is where graphic/textual items (e.g., plans, sections, elevations, schedules, details, notes) used to convey the project design intent are placed. The Drawing Area is broken up into a modular grid for the placement of these items. To identify locations within the Drawing Area, the grid is labeled with characters going in alphabetical order (A, B, C, D, etc.) from lower left to top left and characters going in numerical order (1, 2, 3, 4, etc.) from upper left to upper right. To avoid confusion, the alphabetic characters I and O are not used.

The Border Sheet provided by the Center uses a grid with modules measuring 3 in. × 3 in. This allows the placement of more details, sections, elevations within the Drawing Area. When placing items into the grid, the lower left corner of the item should fall near a grid intersection. Items are not required to fit exactly within the 3 in. × 3 in. module; they are allowed to take up more than one module in the vertical and/or horizontal direction. However, if an item does not fill up a complete module, other items are not allowed to take up the remainder of the module's space (Figure 2-3). Instead, that item should be placed in the next available module (Figure 2-4).

If general notes, keynotes, or key plans are included on a sheet, they should be located in the modules beside the Title Block Area (Modules A10-G10 on the Center's ANSI D-size sheet). The key plan should always be located within the lowest module (A10) of this area.

Note: *The border sheet previously released by the Center had a Drawing Area with five horizontal by five vertical grids, equally spaced. This resulted in limited space for inserting details onto a sheet while still being within the guideline of using whole modules for individual details. Smaller modules allow for the placement of more details on a single sheet.*

Figure 2-3. Incorrect grid module use.

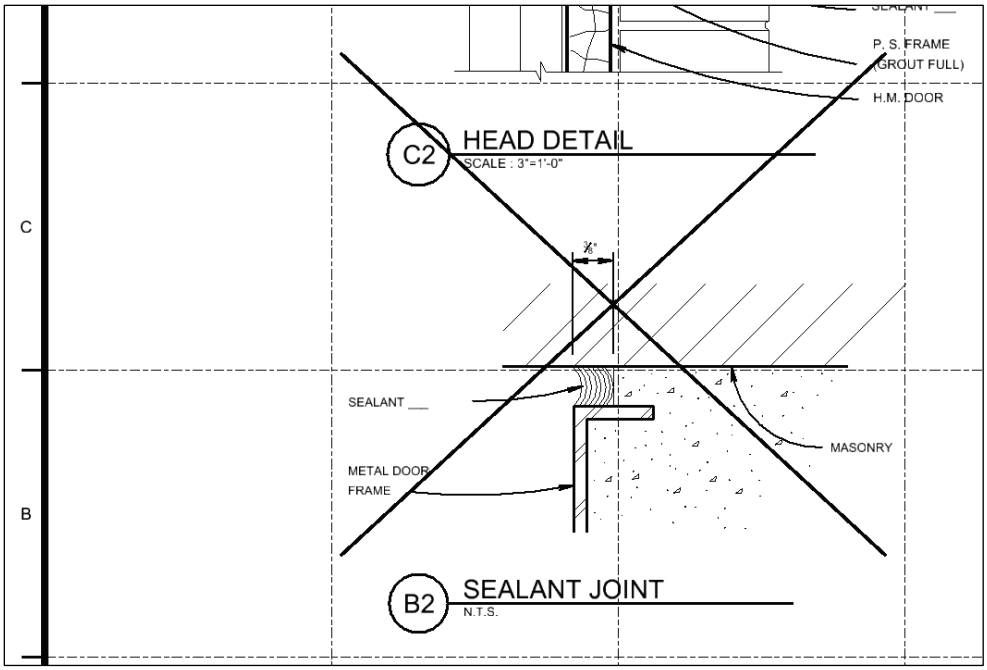
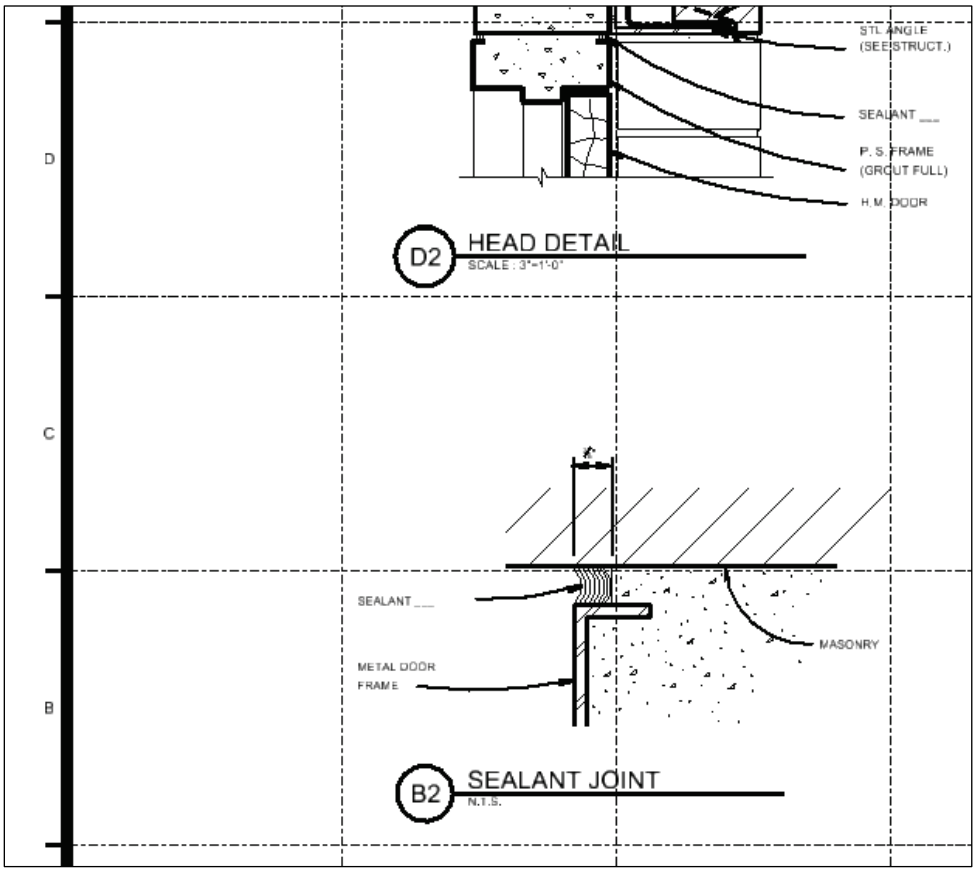


Figure 2-4. Correct grid module use.

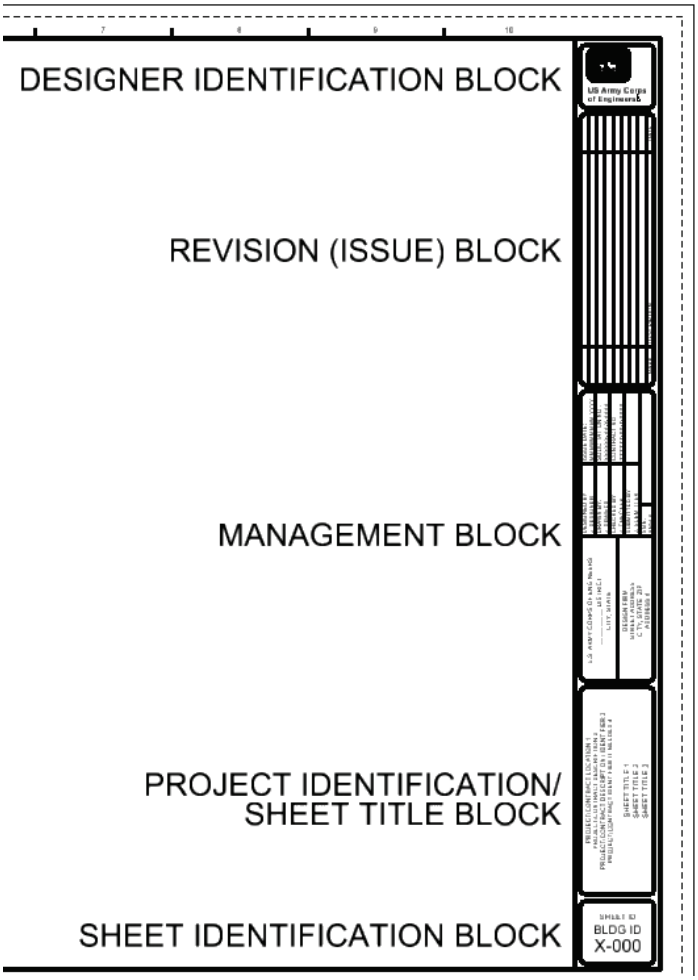


2.1.6 Title Block Area

The Center recommends the use of a vertical title block placed in the right-hand margin of the border sheet as shown in Figure 2-5. Use of a vertical title block allows for the most usable drawing area on a sheet. The vertical title block also ensures the most prevalent and pertinent information remains at the bottom right of the sheet. The title block area will include the following:

- Designer Identification Block
- Revision (Issue) Block
- Management Block
- Project Identification/Sheet Title Block
- Sheet Identification Block.

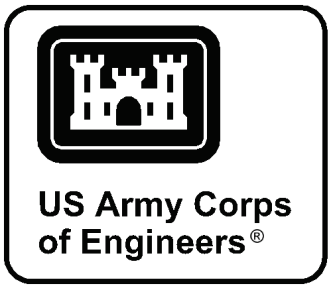
Figure 2-5. Vertical title block.



2.1.7 Designer Identification Block

The Designer Identification Block (Figure 2-6) contains the logo and/or name of the agency that is the owner of the sheet. The Border Sheet available on the CAD/BIM Technology Center's website contains the U.S. Army Corps of Engineers Communication Mark within the Designer Identification Block. No modification of either the symbology or text within the Communication Mark shall be allowed. Districts shall refrain from reducing the size of the Communication Mark to add text identifying their District within the Designer Identification Block. Instead, this information shall be added to the Management Block.

Figure 2-6. Designer Identification Block.



Note: *Using the U.S. Army Corps of Engineers Communication Mark only in the Designer Identification Block provides for consistency within USACE and eliminates duplicating information contained elsewhere on the Border Sheet.*

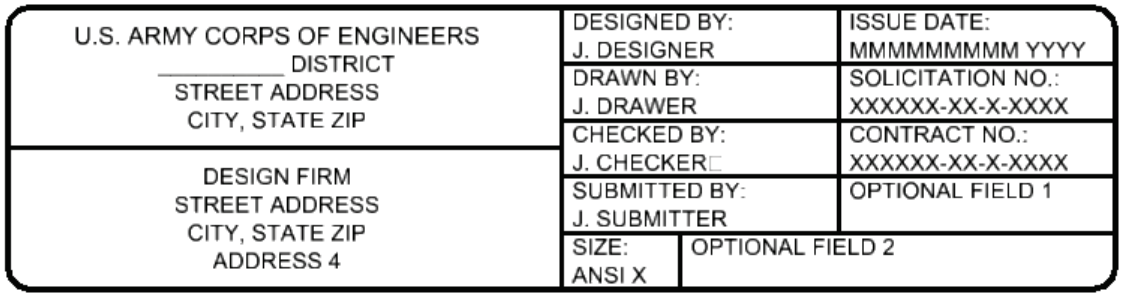
2.1.8 Revision (Issue) Block

See section 7.3 Revision (Issue) Block.

2.1.9 Management Block

The Management Block (Figure 2-7) contains information about the owner, the design firm, sheet data, and project management data. All text placed within this block shall be 3/32 in. high.

Figure 2-7. Management Block.



OWNER: The top left portion of the Management Block is dedicated to the owner of the information (typically the agency responsible for the project). Four lines are provided for this information. The top line shall always read U.S. ARMY CORPS OF ENGINEERS. The second line shall identify the specific District (e.g., VICKSBURG DISTRICT). The third line shall identify the street address of the District (e.g., 4155 CLAY STREET). The fourth line shall identify the city, state, and zip code of the District (e.g., VICKSBURG, MS 39183).

DESIGN FIRM: The bottom left portion of the Management Block shall capture information about the design firm (A-E firm or District) that did the design on that particular sheet. Four lines are provided to provide the name and address of that design firm. If desired, an A-E firm may substitute a logo for this information.

Note: *If a USACE District is performing the design work for another District, the format of the information in the Design Firm portion of the block shall follow the same format as the Owner information. Districts performing design work internally may leave the Design Firm area blank.*

DESIGNED BY: The name of the lead architect or engineer who did the design shall provide his/her information here. The format of the name provided shall be first initial, followed by a period, then full last name (e.g., J. DESIGNER).

DRAWN BY: The name of the person who created the sheet shall provide his/her information here. The format of the name provided shall be first initial, followed by a period, then full last name (e.g., J. DRAWER).

CHECKED BY: The name of the person who verified the data on the sheet is consistent with the design intent shall provide his/her information here. The format of the name provided shall be first initial, followed by a period, then full last name (e.g., J. CHECKER).

SUBMITTED BY: The name of the Project Architect or Project Engineer shall provide his/her information here. The format of the name provided shall be first initial, followed by a period, then full last name (e.g., J. SUBMITTER).

SIZE: The nominal size of the sheet (e.g., ANSI D, ANSI F, ISO A).

ISSUE DATE: The month and year going to advertisement. The format of the date shall be MMMMMMMMM YYYY (e.g., OCTOBER 2014).

SOLICITATION NO.: This section shall be filled with the solicitation for advertisement number. This is always 16 characters in the format XXXXXX-XX-X-XXXX.

CONTRACT NO.: This section shall be filled with the actual **construction** contract award number. Like the solicitation number, the contract number is also 16 characters in the format XXXXXX-XX-X-XXXX.

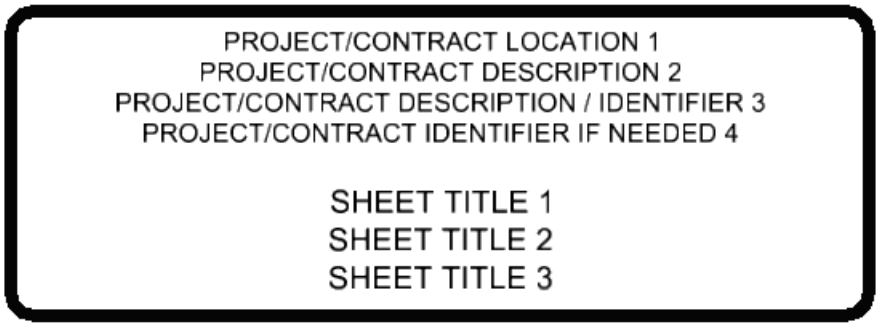
Note: *SOLICITATION NO. and CONTRACT NO. vary depending on if the project is design-build or design-bid-build.*

Note: *Two optional sections are available in the lower right of the Management Block. These sections could potentially be used to record the total number of sheets in the construction document set, to record the number of the sheet in the set, or to capture information such as the file name, facility code, or drawing code. This data shall be defined by the Issuing Agency.*

2.1.10 Project Identification/Sheet Title Block

The Project Identification/Sheet Title Block (Figure 2-8) is comprised of two sets of information: project identification and sheet information. The organization of data in each half of the block reflects a philosophy of moving from general information to specific.

Figure 2-8. Project Identification/Sheet Title Block.



PROJECT IDENTIFICATION: The top half of this block contains information about the project. All text within this part of the block shall be 3/32 in. high. The first line shall provide information about the project location (e.g., FORT LEONARD WOOD, MISSOURI). The second line shall provide a description of the project (e.g., DINING FACILITY). The third line shall provide a project identifier (e.g., P2#, PN#, FY). If more space is required for the description of the project, this description information shall continue into the third line, and the project identifier information shall be provided in the fourth line.

SHEET TITLE: The bottom half of this block contains a description of the content of the sheet. All text within this part of the block shall be 1/8 in. high. The first line shall provide a description of what is presented on the sheet (e.g., REFLECTED CEILING PLAN, FLOOR PLAN). If more than one type of information is presented on the sheet (e.g., plans, schedules, details), the most important information is identified. The second line shall provide what floor the information on the sheet is located (e.g., FLOOR 2, BASEMENT). The third line shall provide specific quadrant location information if required (e.g., ZONE 3, AREA B).

SHEET IDENTIFICATION BLOCK: The Sheet Identification Block (Figure 2-9) contains the sheet identifier. The sheet identifier is composed of the discipline designator, the sheet type designator, and the sheet sequence number (e.g., A-101). The height of the sheet identifier shall be 1/4” high.

Figure 2-9 Sheet Identification Block.

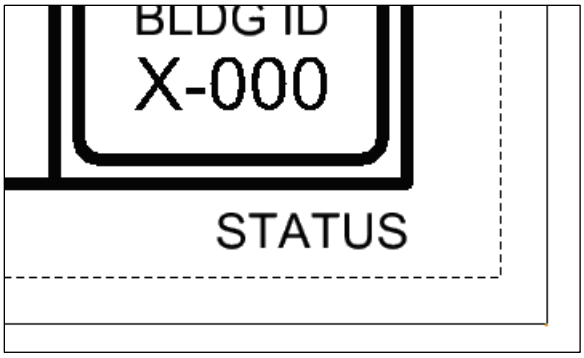
Note: *An optional BLDG ID field is available for those construction projects where the sheet set contains more than one building. If this field is used, identification for that particular building is placed in this field. The height of the building identifier shall be 3/16 in. high. If this field is not used, leave this space blank.*

Note: *"Sheet X of Y" has been removed from the Sheet Identification Block. The primary reason is that the Index Sheet is the prevailing owner of sheet information since it contains a record of every sheet in the drawing set and the drawing set order. Trying to keep "Sheet X of Y" constantly updated becomes a huge burden on the design team during project close out. When pages are added or removed the entire drawing set must be renumbered to modify the page count and sheet numbers. Even on small projects (fewer than 100 sheets) the renumbering process can take several hours to make the necessary changes. Reprinting, reviewing, correcting, and potential reprinting again of all the sheets increases the burden of time and labor on the design team. On larger projects, this renumbering process potentially could take several work days.*

2.1.11 Status

An additional field (Figure 2-10) is available on the Border Sheet for specifying the current status of the project (e.g., 30%, 60%, 90%, READY FOR ADVERTISEMENT, AS AWARDED, AS-BUILT). This information shall be located at the bottom right corner of the Border Sheet and shall be 3/16 in. high.

Figure 2-10. Status field.

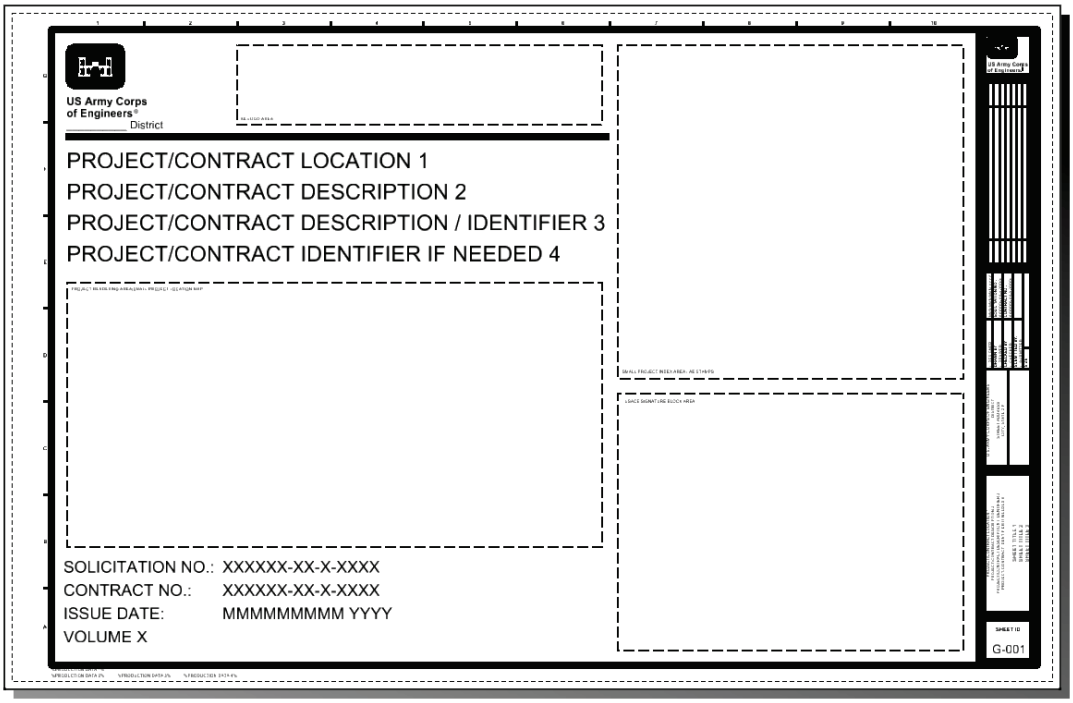


Note: *Status data is specific to each project or design organization. Be sure to contact the organization for details on how this information is to be presented.*

2.2 Cover Sheets

Similar to the cover of a book, a Cover Sheet contains information provided for both informational and promotional purposes. Like the rest of the project set, the Cover Sheet information is contained within a Border Sheet and is always given the Sheet Identifier of G-001 (Figure 2-11).

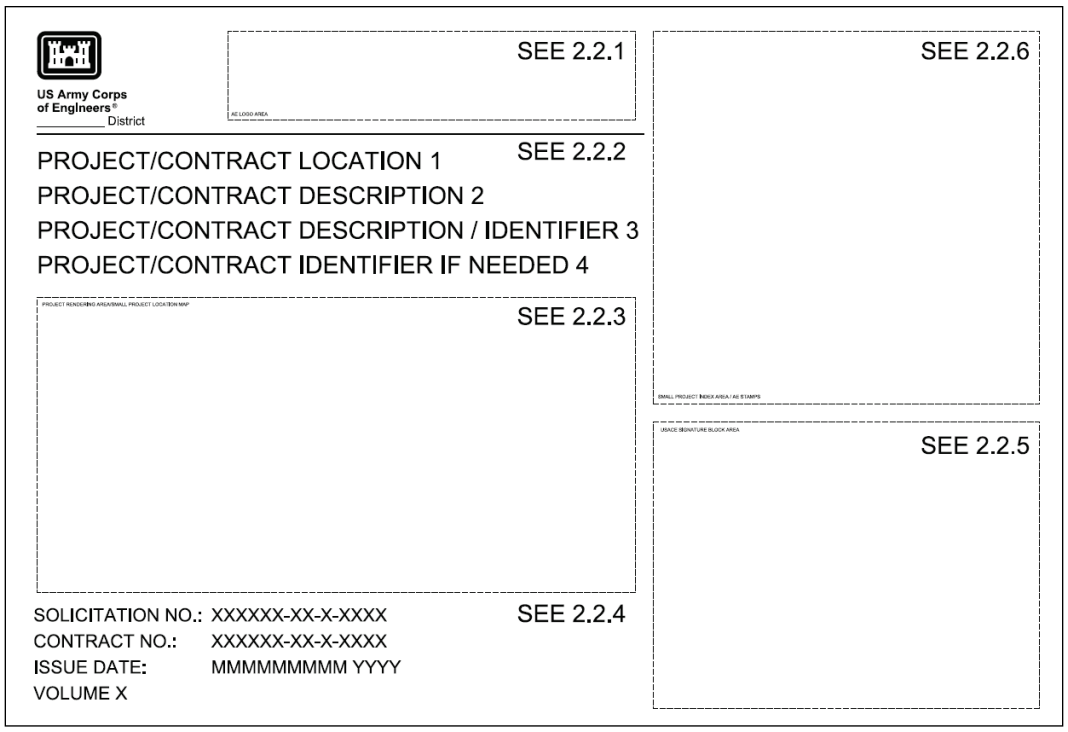
Figure 2-11. Cover Sheet.



Information captured on a Cover Sheet is comprised of mandatory textual information and areas available for promotional/approval/contractual items (Figure 2-12).

Note: *Areas shown inside the dashed lines are intended for visual reference in this section. The dashed lines and text within are NOT intended to be plotted.*

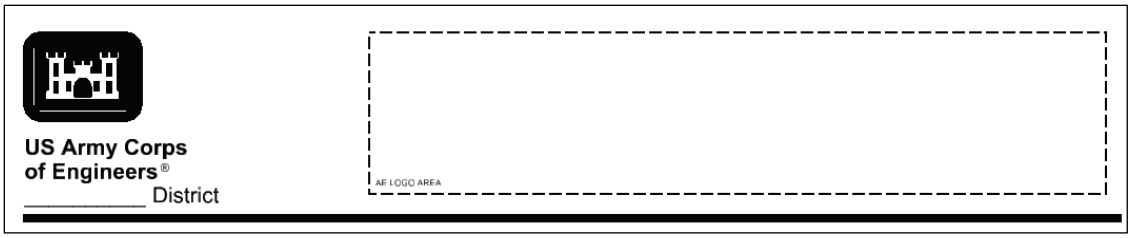
Figure 2-12. Cover Sheet information only.



2.2.1 Owner/Designer information

Starting at the top left of the Cover Sheet and proceeding counterclockwise, the first information that is captured on the Cover Sheet is information about the owner and designer(s) (Figure 2-13). The Owner's logo shall be presented to the far left of this section. For USACE Districts, this logo shall be the U.S. Army Corps of Engineers Communication Mark with 1/4 in. high text directly beneath, identifying the specific District. To the right of the Owner logo, there is an area provided for designer logos. These logos could be another District's logo (using the same U.S. Army Corps of Engineers Communication Mark, with identifying District text) or an A-E's logo. However, the Owner's logo shall always be the largest of the logos provided in this section of the Cover Sheet.

Figure 2-13. Owner/Designer information.

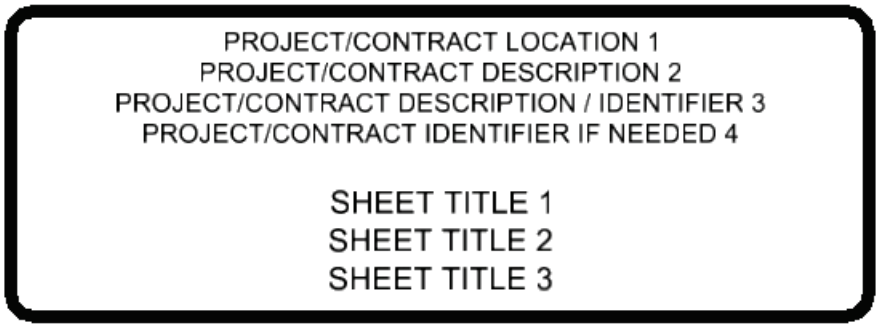


2.2.2 Project/Contract information (Part 1)

Directly below the Owner/Designer Information section, there are four lines of textual information identifying the project/contract (Figure 2-14). The information captured in this section shall be the same information that is shown in the top half of the Border Sheet's Project Identification/ Sheet Title Block. All text in this section shall be 1/2 in. high.

Figure 2-14. Link between Project/Contract information on Cover Sheet and Border Sheet.

PROJECT/CONTRACT LOCATION 1
PROJECT/CONTRACT DESCRIPTION 2
PROJECT/CONTRACT DESCRIPTION / IDENTIFIER 3
PROJECT/CONTRACT IDENTIFIER IF NEEDED 4



2.2.3 Project rendering/Small location map area

Below the Project/Contract Information is a large area (Figure 2-15). This space is available for providing a rendering of the project, showcasing the intended final look. Another possible use for this space is for providing a small vicinity map.

Figure 2-15. Project rendering/small location map area (example rendering shown).

2.2.4 Project/Contract information (Part 2)

The next section of the Cover Sheet is devoted to information about the construction contract (Figure 2-16). Three of these text items shall be the same as information already contained in the Border Sheet's Management Block while the fourth is an optional field.

Figure 2-16. Project/contract information (Part 2) area.

SOLICITATION NO.: XXXXXX-XX-X-XXXX
CONTRACT NO.: XXXXXX-XX-X-XXXX
ISSUE DATE: MMMMMMMMM YYYY
VOLUME X

SOLICITATION NO.: This field shall be filled with the solicitation for advertisement number. This is always 16 characters in the format XXXXXX-XX-X-XXXX.

CONTRACT NO.: This field shall be filled with the actual **construction** contract award number. Like the solicitation number, the contract number is also 16 characters in the format XXXXXX-XX-X-XXXX.

Note: *SOLICITATION NO. and CONTRACT NO. vary depending on if the project is design-build or design-bid-build.*

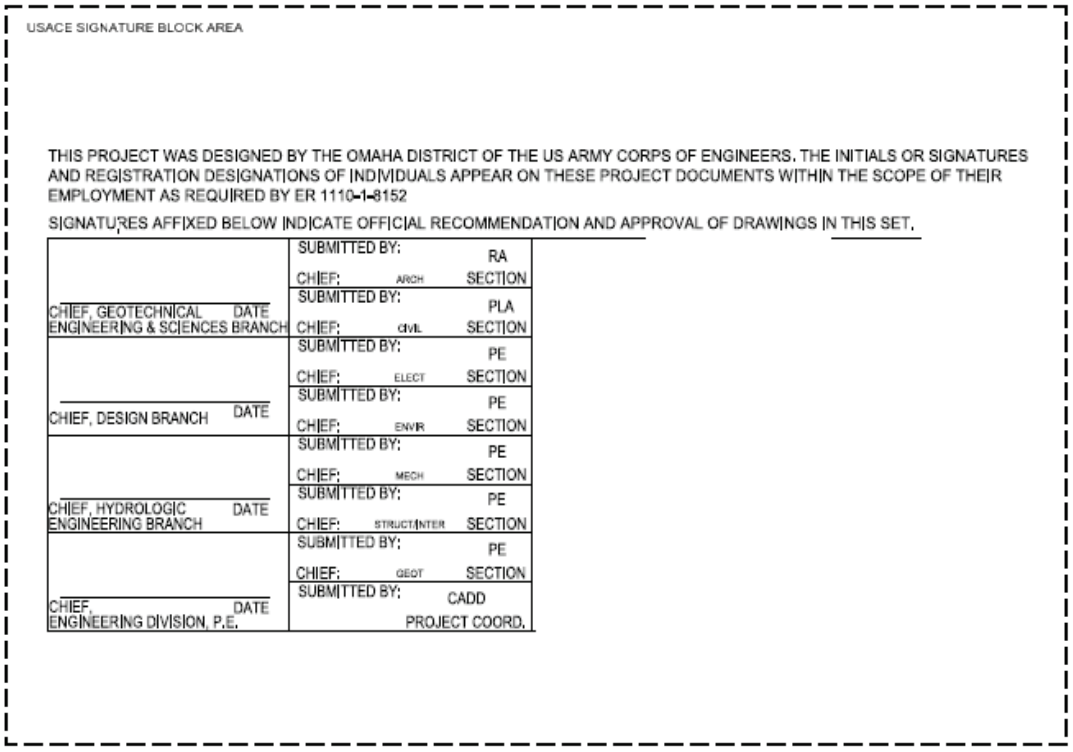
ISSUE DATE: This field is for the month and year going to advertisement. The format of the date shall be MMMMMMMMM YYYY (e.g., OCTOBER 2014).

VOLUME: This field is optional and is available for those projects where more than one volume of contract drawings is required.

2.2.5 Signature Block Area

The bottom right portion of the Cover Sheet is dedicated to any required agency signature blocks (Figure 2-17). These could be signature blocks that cover the entire drawing set, either showing approval and/or review of the set by a District's Chief of Engineering.

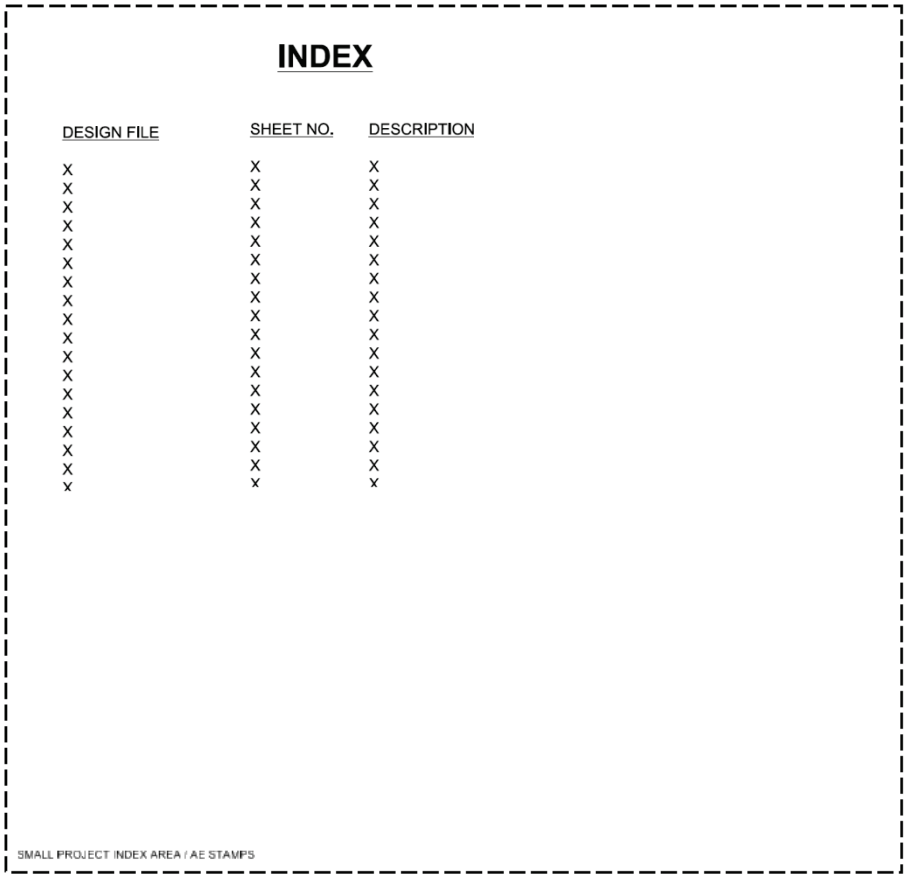
Figure 2-17. Signature Block Area (example signature block shown).



2.2.6 Small project index/A-E stamps area

The last area of the Cover Sheet, contained in the upper right quadrant, is available for either a small project's index of drawings or A-E professional stamps (Figure 2-18).

Figure 2-18. Small project index/A-E stamps area (example index shown).



3 Orientation

3.1 Common

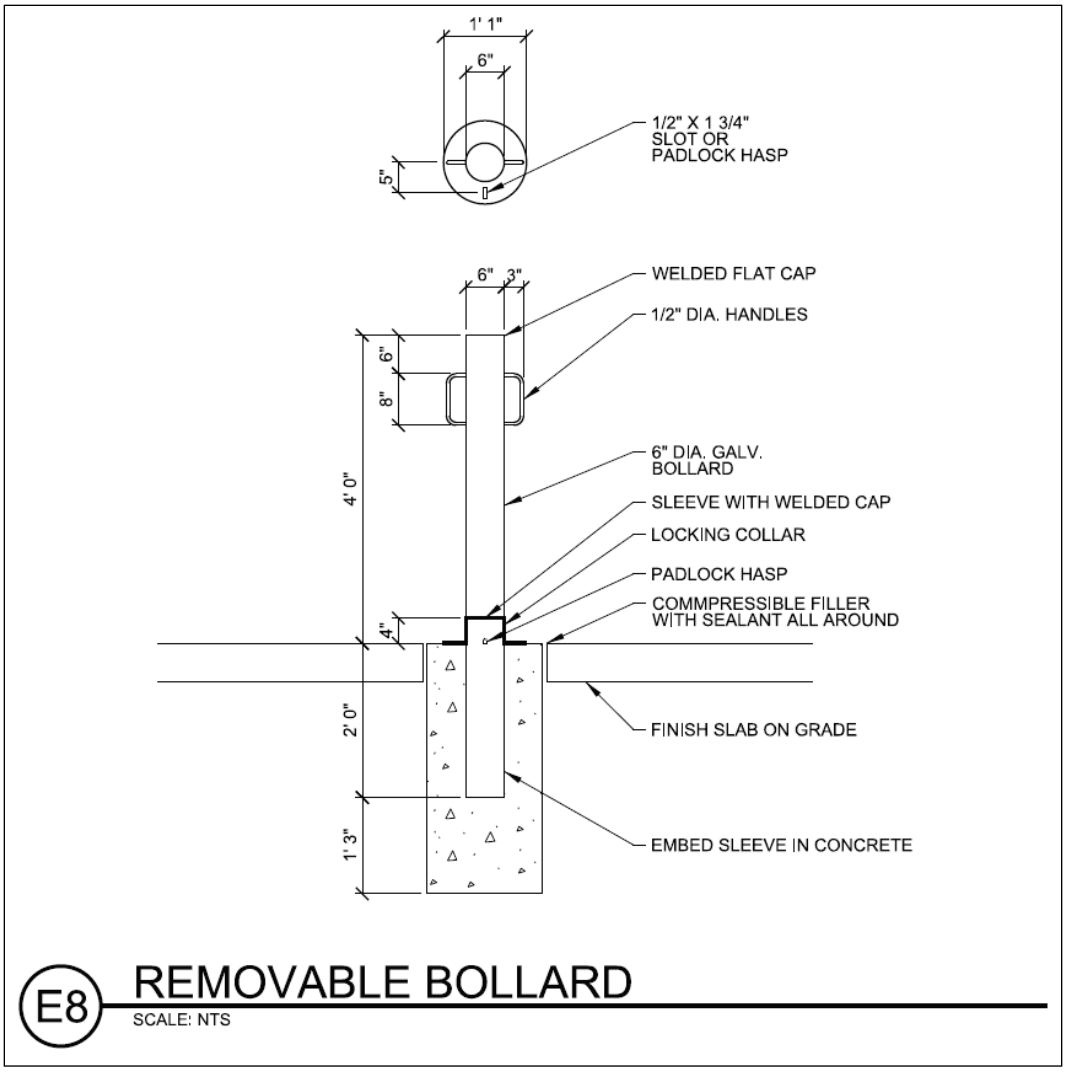
3.1.1 Drawing sheet coordinate system

Drawing sheets have an intrinsic coordinate system, arranged in columns and rows. “Columns are identified with numerical characters starting with 1 and increasing to the right. Rows are identified with alphabetical characters beginning at the bottom with A and increasing toward the top of the sheet” (UDS Module 2 – Sheet Organization (CSI 2014). The drawing coordinate system is used to identify/discuss drawing objects.

3.1.2 Plans, elevations, and details

Views shall be oriented on the sheet so that elevations and features are aligned whenever possible. When detailing is being added, details shall appear on the sheet based on their orientation on the feature. For instance, the top view of a detail shall be oriented above the front view of the same detail (Figure 3-1). If a detail is taken from a large-scale plan or elevation, the orientation shall remain the same as the view from which the cut was taken. If this is not possible, a note stating that the orientation was changed shall be added (e.g., VIEW ROTATED 90 DEGREES). When two or more plans of the same structure or the plans of two or more different structures are put on the same drawing, the orientation of all must conform to one another and to their relative positions on the ground.

Figure 3-1. Proper orientation of detail views.



3.2 Horizontal

3.2.1 Project coordinate system

The specified coordinate system/datum (usually State Plane) used for the project shall be denoted on maps (civil plans). Coordinates shall be identified using tick marks, which are oriented to show north, south, east, and west. Northings and eastings shall be shown along the edges of the plan view boundary at the beginning of the plan set or on every sheet (Figure 3-2). The grid system used shall be described in the general notes (Figure 3-3).

Figure 3-2. Northings and eastings along edge of plan view boundary (example shown).

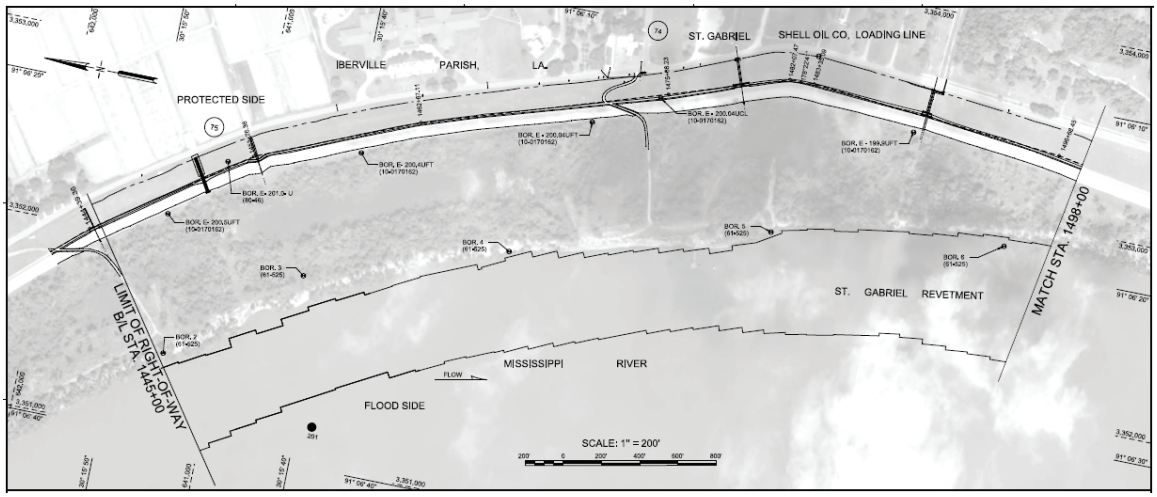


Figure 3-3. Grid system described in general notes (example shown).

GENERAL NOTES:

1. THE DESCRIPTIONS OF HORIZONTAL AND VERTICAL CONTROL POINTS ARE AVAILABLE FROM THE NEW ORLEANS DISTRICT SURVEY SECTION
2. ORIGINAL DATA COMPILED NAD 83 US SURVEY FOOT UNLESS OTHERWISE NOTED.
3. INSIDE PLAN AREAS, POLYCONIC PROJECTION 1983 NORTH AMERICAN DATUM IS REPRESENTED BY SOLID TICKS AND LAMBERT CONFORMAL CONIC PROJECTION IS REPRESENTED BY DASHED TICKS.
4. XY COORDINATES USED IN DRAWINGS REFER TO HORIZONTAL DATUM: NAD 83, STATE PLANE, LA SOUTH, ZONE 1702, US FEET.
5. AERIAL PHOTOGRAPHY FLOWN IN 2007.
6. AZIMUTHS SHOWN ARE MEASURED CLOCKWISE FROM THE NORTH.

3.2.2 Vicinity maps

Vicinity maps shall be oriented with true north toward the top of the sheet.

3.2.3 Maps and drawings

Civil works maps and drawings shall be oriented so that plan north is toward the top of the sheet when practicable or toward the left when impracticable.

3.2.4 Channels, locks, and dams

General plans, elevations, and longitudinal sections of channels, locks, dams, and similar structures shall be oriented with the direction of water

flow from top to bottom of the sheet, if practicable, or from left to right. Detailed plans shall be oriented with the direction of water flow from top to bottom. Plans and profiles of floodgates in levee construction shall be oriented with the observer looking downstream. Cross sections of locks shall be shown as if the observer were looking downstream, except in special cases where an upstream view would better clarify a complex positioning of adjoining elements. Typical dam sections shall be shown with the upstream side on the left and the downstream side on the right. The words UPSTREAM and DOWNSTREAM shall be shown in their proper places at the top of the sections.

3.2.5 Waterways

Included under this heading are new channels and channel improvements such as channel clearing and snagging, cleanout, enlargement, and realignment (cutoffs). Detailed plans shall be oriented with the direction of water flow from top to bottom of sheet, if practicable, or from left to right (Figures 3-4 and 3-5). The direction of water flow for all waterways shall be indicated by arrowheads at the upper and lower limits of the sheet, pointing in the direction the water flows.

Note: *For coastal projects with tidal flows rather than river flows, all channel sections are oriented looking inshore, which is usually also looking toward increasing stations. Typically, labeling for port entry channels begins offshore with negative stations and increases inshore with station 0+00 at the crossing of the shoreline into a landlocked channel. Stations continue to increase inshore/upstream. However, it is recommended that users research specific District requirements to follow proper District procedure.*

Channel cross sections shall be shown as if the observer were looking downstream. The words LEFT BANK and RIGHT BANK shall be shown in their proper places at the top of the sections (**Note:** *River banks are always determined as being right bank or left bank by facing in direction of water flow*). Where cross sections are plotted on a common center line, the words LEFT BANK and RIGHT BANK need to be shown but once, on the top section only.

Figure 3-4. Orientation of water flow in waterways.

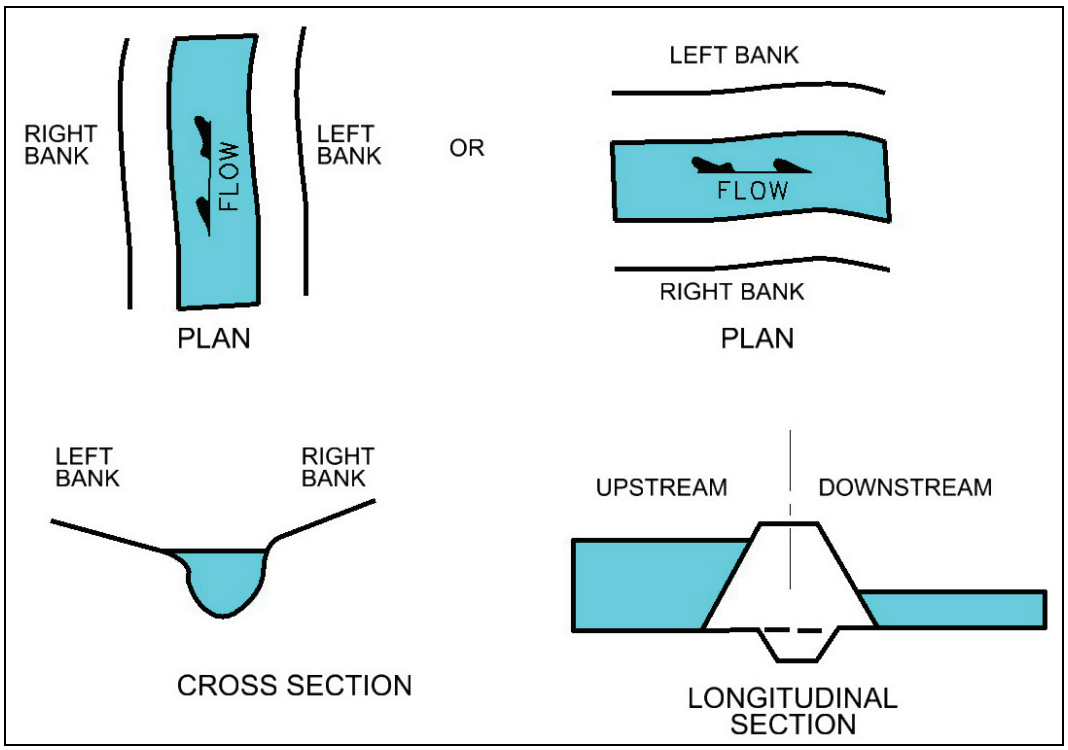
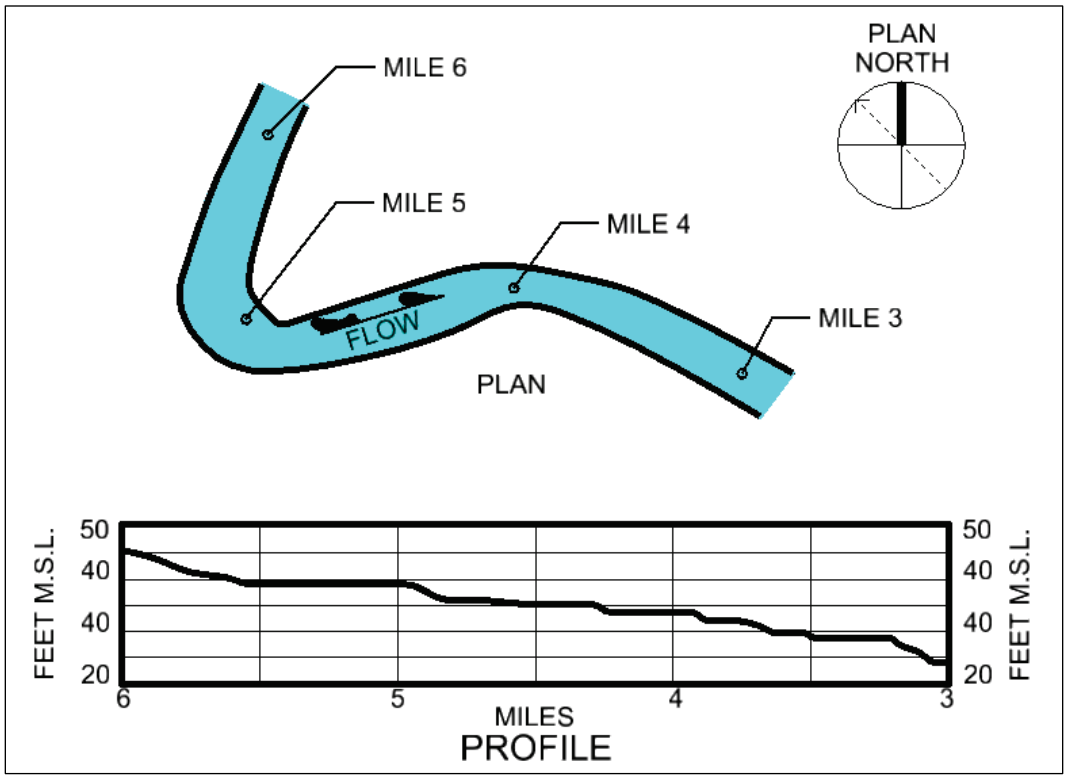


Figure 3-5. Orientation of water flow in plan and profile.



When two or more plans of the same structure or the plans of two different structures are put on the same drawing, the orientation of all must conform to one another and to their relative positions on the ground.

Some construction drawings of flood control projects will require the section to be shown looking upstream. For instance, downstream elevations will be unique for some projects and drawn in projection.

3.2.6 Levees

Detailed plan maps of levees, dikes, berms, and slide repairs shall be oriented with the stream side (unprotected side) at the top of the sheet, irrespective of stream flow. All levee cross sections shall be plotted looking in the direction in which the stations increase. The words LANDSIDE and WATERSIDE shall be shown in their proper places at the top of all plotted sections. Where cross sections are plotted on a common center line, the words LANDSIDE and WATERSIDE need be shown but once, on the top section only.

Note: *Because of channel orientation and irregular shapes of leveed dredged material placement areas (PA), plans are sometimes oriented*

1. *to match channel orientation (stationing increasing right to left) allowing the channel to be shown either above or below the PA*
2. *to best fit the irregular shape to the plan sheet trying to best maintain the north up/left orientation.*

3.2.7 Roadways and other structures

General plans, elevations, and longitudinal sections of roadways and other structures shall be oriented so that north is toward the top of the sheet or toward the right of the sheet if top orientation is impracticable. Stationing shall be from west to east or south to north. Cross sections shall be shown as if the observer were looking up station. Stationing shall read up station.

3.3 Vertical

3.3.1 Column grid system

A grid system is used to indicate structural columns, load-bearing walls, shear walls, and other structural elements on the drawings. It is used primarily for reference in schedules of structural data. A

grid system is also used if the design of a building is based on a module system, regardless of the structural system. Grid lines are used as a basis for dimensioning. Proper planning and layout of a drawing on the selected sheet size requires the accommodation of alphanumeric grid designations within column indicators. Vertical grid lines shall have designators at the top of the grid numbered from left to right. Horizontal grid lines shall have designators at the right side of the grid alphabetized from bottom to top. To eliminate confusion with the numerals 0 (zero) and 1 (one), do not use letters O or I (UDS Module 4 – Drafting Conventions [CSI 2014]).

Where additional intermediate structural support elements occur between grid lines, a [decimal] designation is used. For example, a column occurring at midpoint between grid lines 2 and 3 would be designated 2.5. In a similar manner, columns occurring between grid lines A and B would be represented as A.1, A.2, A.3, and A.4 (UDS Module 4 – Drafting Conventions [CSI 2014]).

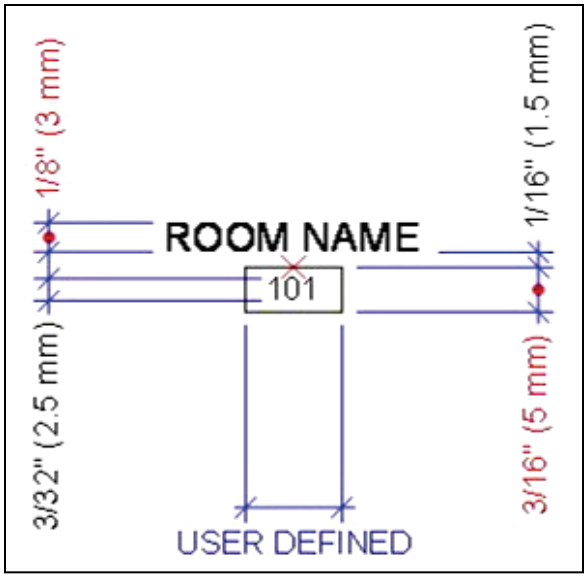
3.3.2 Numbering of floors

The ground floor shall be designated as the first floor. All occupied floors above the first floor are to be numbered sequentially upward (second floor, third floor, fourth floor, etc.). The floor below the first floor is considered to be a basement and should be designated as B1. Subsequent floors below B1 are numbered sequentially (B2, B3, B4, etc.). The topmost floor of the building that does not contain office or habitable space is designated as the attic (typically this area contains structural framing and HVAC equipment/ducts).

3.3.3 Numbering of rooms

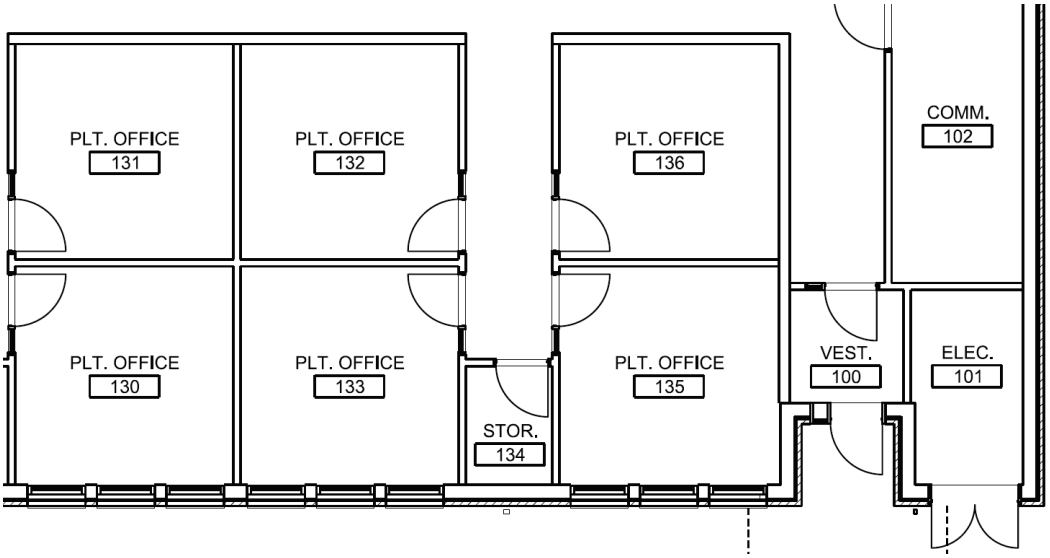
All floor plans (except structural) shall show room identifiers (Figure 3-6). The first part of a room identifier shall match the floor number. Typically, room numbering starts at the most prominent means of access (e.g., main entrance, elevator, or stair) to the floor and proceeds sequentially. For instance, if the building is a single-story structure, then the first room to the right of the main entrance would be 101. If the main entrance opens into a lobby or vestibule, then the lobby would be numbered 100, and numbering would continue sequentially with the first room to the right (Figure 3-7).

Figure 3-6. Room identifier symbol.



Note: *Room numbers on construction documents are typically for construction references and do not necessarily reflect the final room numbers. See the Signage schedule for final room number/names. It is recommended that the architect consult the building owner before beginning room numbering.*

Figure 3-7. Room numbering example.

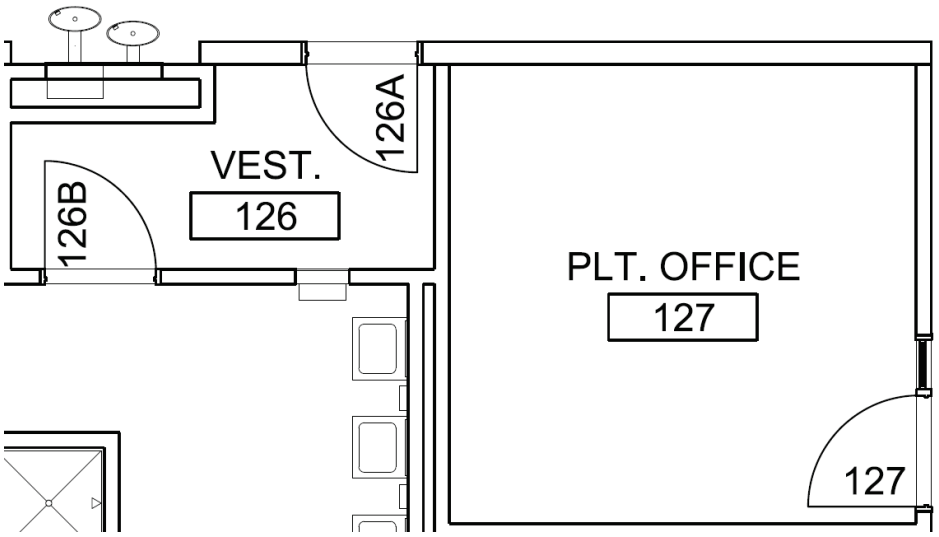


3.3.4 Numbering of doors

Each door opening in a building shall have a 3/32 in. (2.4 mm) text unique identifier. For rooms that have one door opening, the door opening

number shall be the same as the secure side room number. If more than one door opening in a room exists, door openings within that room shall be identified by the room number followed by an alphabetical character starting clockwise from the corridor access door opening. For example, for Room 126 (Figure 3-8), the corridor access door opening would be numbered 126A and the second door opening within Room 126 would be numbered 126B.

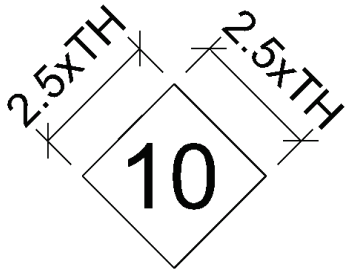
Figure 3-8. Numbering of doors.



3.3.5 Identification of windows

Each type of window shall have a unique identifier (Figure 3-9). The window identifier symbol with identifier number and/or letter shall also be placed in the Mark column of Window Schedules that are developed.

Figure 3-9. Window identifier symbol.



3.3.6 Numbering of stairs

The most prominent stair with the largest egress capacity shall be identified with 3/32 in. (2.4 mm) high text as STAIR 1. On the first floor, number the stairs sequentially moving clockwise from the first stair. The stair number remains the same for its entire height. Stairs above or below the first floor that do not connect with the first floor are numbered following those that do. If several prominent stairs with large egress capacity exist, the stairs may be numbered in order of their importance to the main egress point in the building. Additional stairs may be numbered as described.

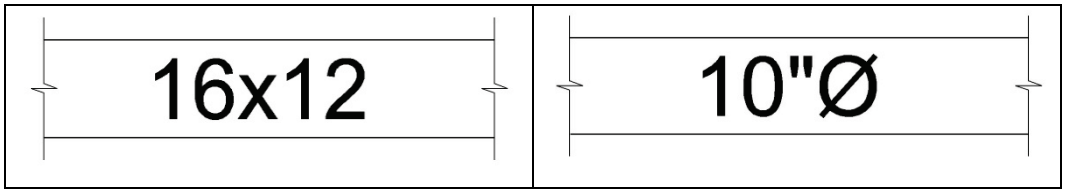
3.3.7 Numbering of elevators

The elevator nearest to the building entrance with the largest access and egress capacity shall be identified with 3/32 in. (2.4 mm) high text as ELEVATOR 1. Number additional elevators moving clockwise within elevator banks. Use the same sequence and arrangement of numbers on additional banks of elevators if present.

3.3.8 Labeling of duct

The SMACNA labels rectangular duct as shown in Figure 3-10a (SMACNA 2001). The first value represents the side of the duct shown (width), and the second value represents the side of the duct not shown (depth). Round duct is shown as the diameter of the duct, followed by a diameter symbol (Figure 3-10b).

Figure 3-10. Duct labeling.



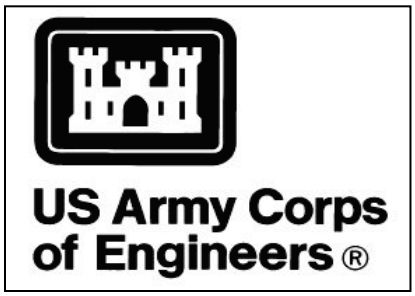
a. Rectangular duct. b. Round duct.

4 Drawing Symbology

4.1 Corps Castle

The appearance of the U.S. Army Corps of Engineers Communication Mark (commonly known as the Corps Castle) has very specific requirements (Figure 4-1). Customized versions of the Communication Mark for individual USACE organizations are prohibited, unless the purpose is for "employee morale welfare activities." The Communication Mark is trademarked, and the ® symbol is to be included "when reproducing printed promotional material that is intended for public usage."

Figure 4-1. U.S. Army Corps of Engineers Communication Mark (commonly known as the Corps Castle).



The "US Army Corps of Engineers®" text located underneath the Communication Mark shall be aligned with its left edge. If a Field Operating Activity (FOA) signature is added to the Communication Mark (Figure 4-2), the text shall always be placed below the "US Army Corps of Engineers" text. For more information on the Corps Castle Communication Mark go to http://www.publications.usace.army.mil/Portals/76/Publications/EngineerPamphlets/EP_310-1-6.pdf.

Figure 4-2. Placement of FOA signature in Corps Communication Mark.

4.2 Symbols

4.2.1 Symbol descriptions

Symbol descriptions, located anywhere in a drawing set, shall adhere to the following basic guidelines to allow their repetition from job to job, preclude conflicts within the drawings, and maximize suitability for CAD interface:

- Symbol descriptions in legends shall be concise and worded in a comma-separated structure that flows from the general to the specific. For example, in lieu of wording the description of a convenience receptacle as WALL-MOUNTED, DUPLEX RECEPTACLE, structure the wording as RECEPTACLE, DUPLEX, WALL-MOUNTED.
- The symbol description shall not contain specific information that would normally be contained in equipment schedules or on the plans.
- Where equipment or devices within a room are all identical, one symbol shall be identified with the full type identifier, and other information and a callout shall be referenced to this symbol with the following words: TYPICAL FOR THIS ROOM. TYPICAL, when used by itself, applies to everywhere a symbol is used in a drawing set unless otherwise noted.

4.2.2 Symbol identifiers

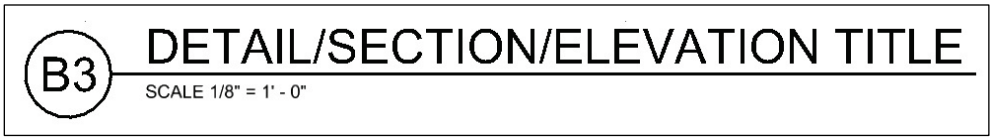
Identifying letters within and around symbols must be legible at one-half normal size. Therefore, letter sizes for symbols shall be a minimum of 3/32 in. (2.4 mm) for that symbol.

4.2.3 Drawing area title

4.2.3.1 Drawing area title identification and placement

The drawing area title is composed of multiple pieces. The identification is a bubble with a combination alphabetic/numeric identification (Figure 4-3). The alphabetic/numeric identification is based on where the detail area title is placed on the sheet grid in the drawing area (see "Border Sheets"). For instance, if the lower left corner of a detail is placed close to the intersection of sheet grid row B and sheet grid column 3, then the detail identification becomes B3. That identification is also used in the top half of the detail/section/elevation indicator symbols.

Figure 4-3. Drawing area title identification symbol.



The decision on where to place the drawing area title within the drawing area of the sheet shall be based on priority and convenience:

> [When placing details, sections, or elevations,] locate the most frequently used referenced drawing block at the lowest drawing module adjacent to the title or notation block [bottom right portion of the drawing area]. Add additional drawings in order of priority, from bottom to top and from right to left. Starting the drawings from the right to the left makes it easier to use partially filled sheets. This eliminates the need to open a heavy set of drawings all the way to the binding to refer to a few details drawn on the left-hand side of the sheets (UDS Module 4 – Drafting Conventions [CSI 2014]).

Note: *When only one subject appears on a drawing, and its title already appears in the title block, a drawing area title shall also be placed under the entire area of the subject.*

Note: *For consistency and uniformity, multiple details with subtitles are no longer allowed in the same drawing area. Details are to be a single subject matter. Additional information can be added as a note.*

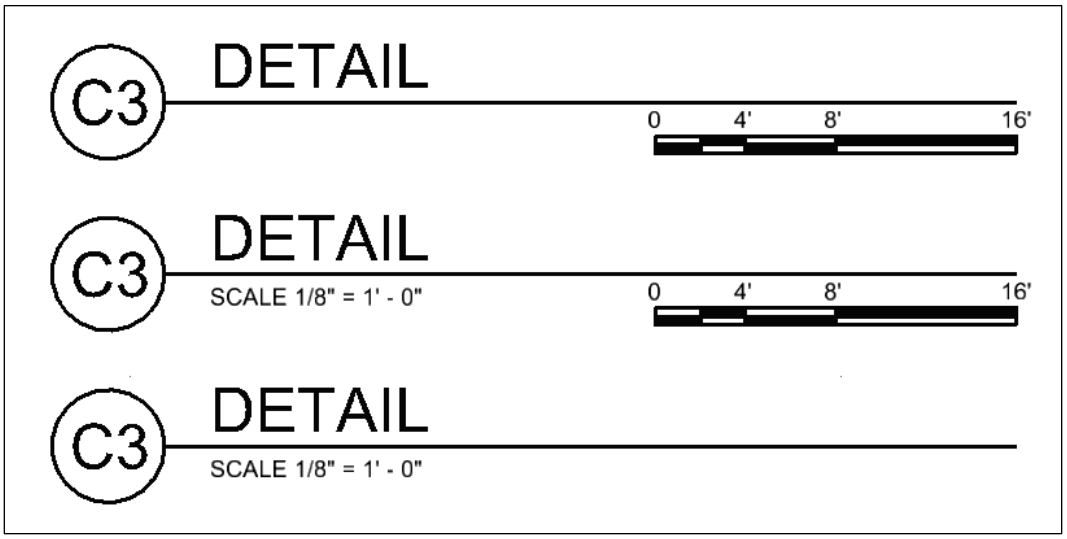
4.2.3.2 Drawing area title text

All text placed in the drawing area title shall be Arial. The height of the text within the bubble and on the drawing area title line shall be 1/4 in. The scale text underneath the drawing area title line shall be 3/32 in.

4.2.3.3 Scales

The scale or scales used for a drawing shall be stated in words and/or figures under the Drawing Block Title of each plan, elevation, section, part, or detail (Figure 4-4). If one or more scales are used on a sheet, a graphic scale or scales must appear on the sheet for each scale used on that sheet. This will ensure that if a sheet is plotted, the sheet can be verified as plotted to the correct scale. When used, the drawing scale text shall be placed at the bottom left of the drawing title, and/or the graphic scale shall be placed on the bottom right of the drawing title as shown in Figure 4-4.

Figure 4-4. Three acceptable methods for showing scales.



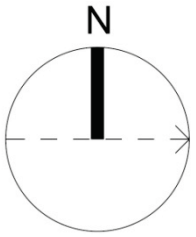
When a drawing is not drawn to any particular scale, the words SCALE: NTS shall be so stated, where NTS indicates Not To Scale.

4.2.3.4 North arrow

A north arrow shall be provided on all Sheet Files where a plan or partial plan is being shown. A north arrow is not required on Sheet Files containing only nonplan items such as riser diagrams, schematic diagrams, or one-line diagrams.

The north arrow (Figure 4-5) shall be placed in the lower right-hand corner of the drawing area. Floor plans shall be oriented so that the plan north arrow points to the top of the drawing block. The true north arrow (i.e., points to the North Pole) is adjusted so that the building grid and plan north arrow are parallel to the sheet orientation. If possible, the orientation of true north shall be maintained throughout an entire drawing set.

Figure 4-5. North arrow



4.2.4 Elevations, sections, and details

4.2.4.1 Elevation/section/detail indicator symbol

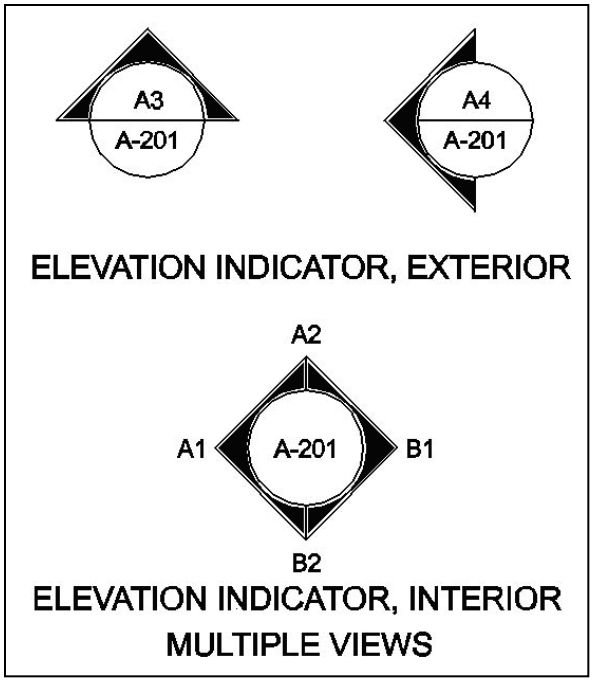
The symbology for elevation, section, and detail callouts may be different, but the procedure for identifying and naming them is essentially the same. The elevation, section, or detail is called out in a drawing with a two-part symbol that identifies the following:

- the elevation/section/detail identification
- the sheet on which the elevation/section/detail is located.

4.2.4.2 Elevation indicator symbol

The elevation indicator symbol (or callout) is a two-part symbol that indicates an area of the drawing that shall be shown in an elevation on the elevations sheet (Figure 4-6). As mentioned previously, the top part of the circle is filled in with the elevation identification, and the bottom part is filled in with the sheet number on which the elevation occurs. The sheet number shall always be an XX2NN designation where XX is the Discipline Designator, 2 indicates it is an Elevations sheet, and NN is the Sheet Sequence Number (01-99).

Figure 4-6. Elevation indicator symbol.



4.2.4.3 Section indicator symbol

The section indicator symbol (or callout) is a two-part symbol that cuts through an area of the drawing that shall be shown in a section cut on the sections sheet (Figure 4-7). As mentioned previously, the top part of the circle is filled in with the section identification, and the bottom part is filled in with the sheet number on which the section occurs. The sheet number shall always be an XX3NN designation, where XX is the Discipline Designator, 3 indicates it is a Sections sheet, and NN is the Sheet Sequence Number (01-99).

4.2.4.4 Detail indicator symbol

The detail indicator symbol (or callout) is a two-part circle that points to an area of the drawing that shall be enhanced in a detail on the details sheet (Figure 4-8). As described previously, the top part of the circle is filled in with the detail identification, and the bottom part is filled in with the sheet number on which the detail occurs. The sheet number shall always be an XX5NN designation where XX is the Discipline Designator, 5 indicates that it is a Details sheet, and NN is the Sheet Sequence Number (01-99).

Figure 4-7. Section indicator symbol.

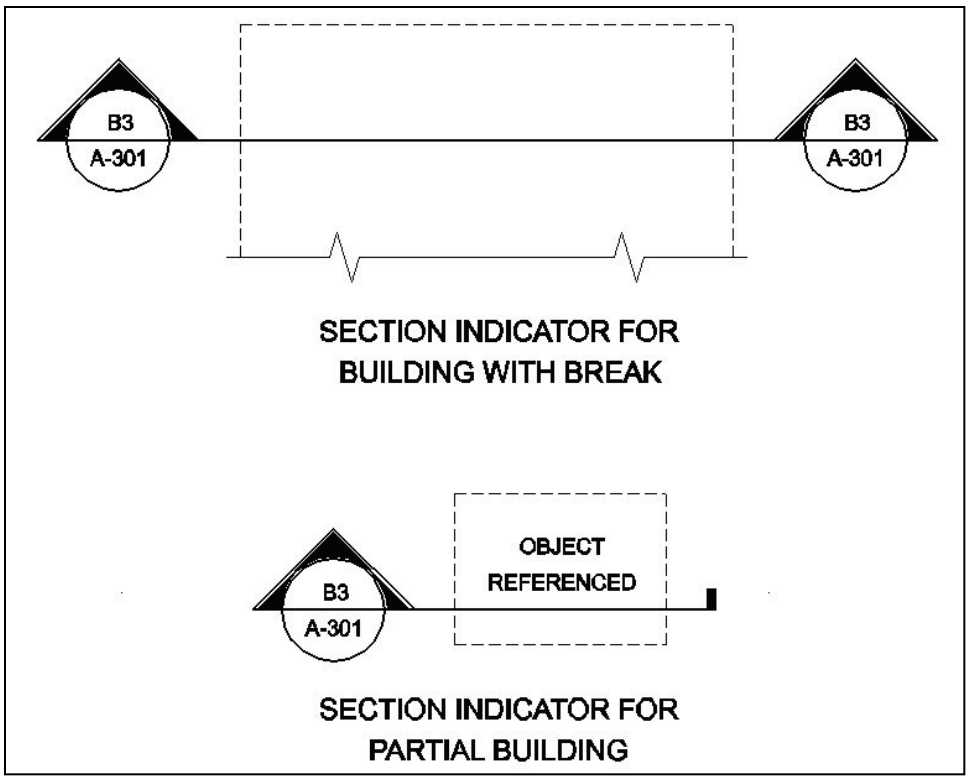
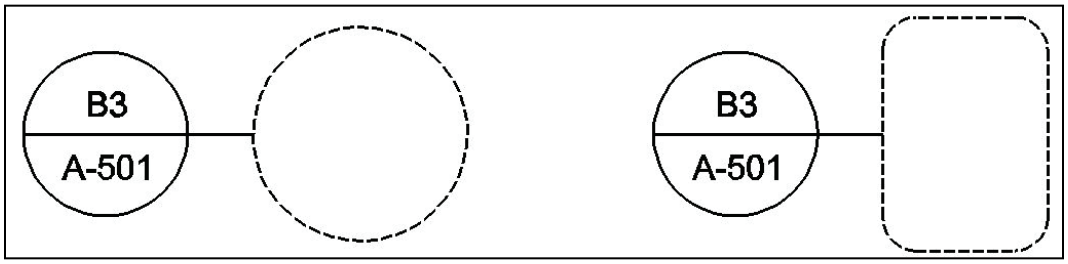


Figure 4-8. Detail indicator symbol.



4.2.5 Welding symbols

When typical weld symbols are developed, the following drafting convention shall be followed (Figures 4-9 and 4-10 and Table 4-1).

The numbers in Figure 4-9 are keyed to the following list:

1. Finishing symbol
2. Contour symbol
3. Groove angle: includes angle of countersink for plug welds
4. Root opening: depth of filling for plug and slot welds
5. Groove weld size
6. Depth of bevel: size or strength for certain welds

7. Specification, process, or other references
8. Tail (may be omitted when reference not used)
9. Length of weld segment
10. Pitch (center-to-center spacing) of weld segments
11. Field weld symbol (flag always points to tail of weld symbol)
12. Arrow connecting reference line to arrow side member of joint or arrow side of joint
13. Reference line
14. Basic weld symbol or detail reference
15. Number of spot, seam, stud, plug, slot, or projection welds
16. Weld-All-Around symbol

Figure 4-9. Typical welding symbols.

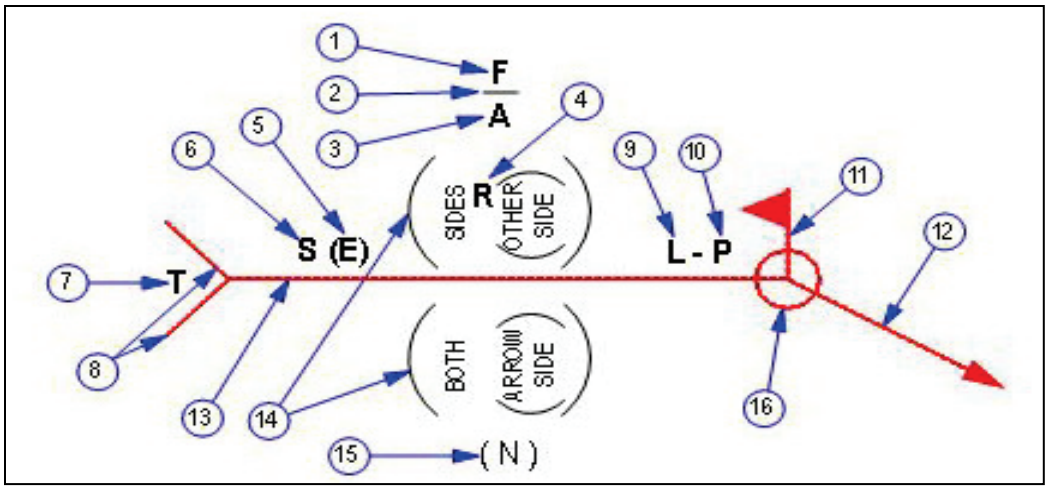


Figure 4-10. Weld symbols.

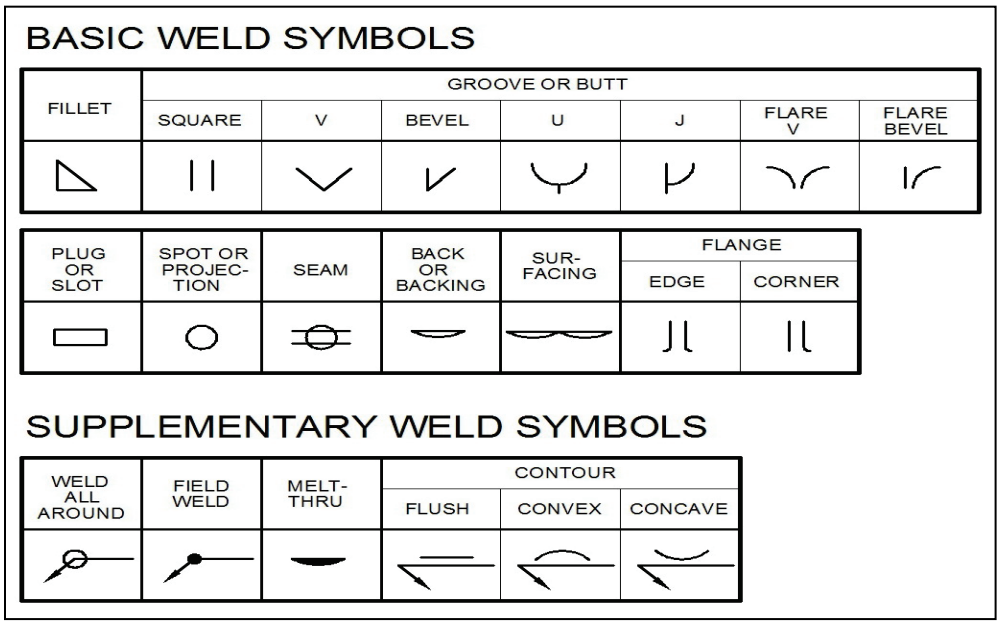


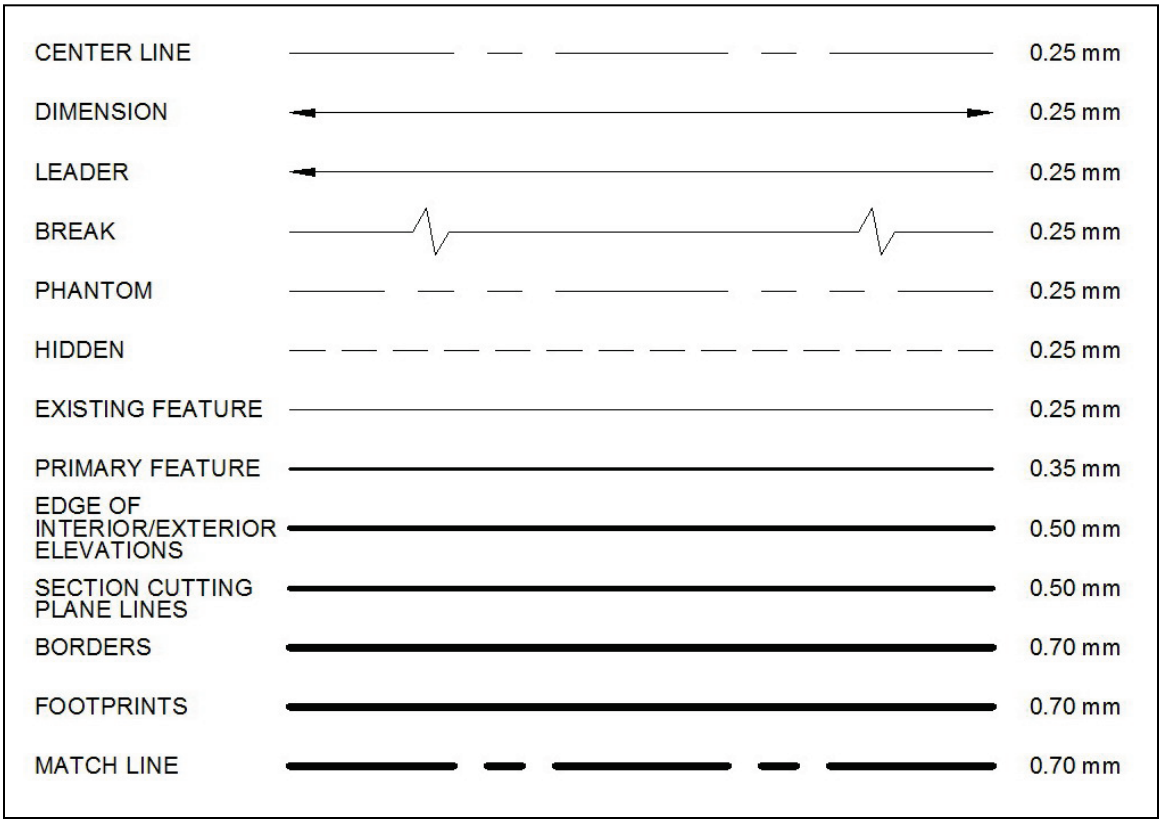
Table 4-1. Common welding processes.

Process	Abbreviation
Arc Welding	
Electrogas welding	EGW
Flux cored arc welding	FCAW
Gas metal arc welding	GMAW
Gas tungsten arc welding	GTAW
Plasma arc welding	PAW
Submerged arc welding	SAW
Shielded metal arc welding	SMAW
Resistance Welding	
Flash welding	FW
Resistance welding	RW
Oxyfuel Gas Welding	
Oxyfuel gas welding	OFW
Solid-State Welding	
Diffusion welding	DFW
Friction welding	FRW
Brazing	
Dip	DB
Diffusion	DFB
Furnace	FB
Induction	IB
Infrared	IRB
Resistance	RB
Torch	TB
Other Welding	
Electron beam welding	EBW
Electroslag welding	ESW
Laser beam welding	LBW

4.3 Linework

Various types of lines require specific line weights. Some of those line types and associated line weights are shown in Figure 4-11.

Figure 4-11. Types of lines and associated line weights.



Center Lines: Center lines ("014200-914 Center Line" in the *A/E/C CAD Standard*) are used to indicate the travel of a center. Center lines shall cross without voids. Short center lines may be unbroken if there is no confusion with other lines.

Dimension Lines: Dimension lines are used to show a linear measurement indicated on a drawing. Dimensions show the extent and significance of the object.

Leaders: Leaders shall be used to indicate a part or portion to which a number, note, or other reference applies.

Break Lines: Break lines are used to indicate that only a portion of a drawing or a partial view is being shown.

Phantom Lines: Phantom lines ("014200-915 Phantom Line" in the *A/E/C CAD Standard*) shall be used to indicate the alternate position of parts, repeated detail, or the relative position of an absent part.

Hidden Lines: Hidden lines ("014200-913 Hidden Line" in the *A/E/C CAD Standard*) are used to show the hidden features of a part or object. Relevances for clarity must be considered. Crossing and stacked hidden lines shall be avoided.

Existing Features: Existing feature lines are used for all lines on the drawing representing objects or structures that already exist and will impact the design. Existing feature lines are typically shown screened.

Primary Features: Primary features represent all new work in the design documents.

Edge of Interior/Exterior Elevations: The edges of interior/exterior elevations are the outlines around the perimeter of an elevation.

Section Cutting Plane Lines: Cutting plane lines shall be used to indicate a plane or planes in which a section is taken.

Borders: Border lines are used to create a margin on the drawing sheet.

Footprints: Footprints show the outline of a building or other object within the drawing.

Match Lines: Match lines (use "014200-914 Center Line" in the *A/E/C CAD Standard*) are used to show where part of a drawing that is too large to be contained on one sheet matches the continuation of that drawing on another sheet.

4.3.1 Showing work conditions within a drawing

4.3.1.1 New work versus demolition work

For clarity in as-built drawings, plan views of demolition work shall not be combined with those for new work. Demolition plans shall not show features that have no contractual significance to the work in the construction contract. Notes shall state that all items shown on the demolition plans will be removed unless noted or specified. Notes, key

notes, symbol modifiers, patterns, line styles, or callouts shall be used to delineate items to be removed or relocated.

4.3.1.2 New work versus existing conditions

New work shall be easily distinguishable from other information shown on the drawings. Show new work at 100% (unscreened), and show existing conditions, including text, screened at a percentage between 20% and 60%. This screening is performed so that the new work will stand out from the existing conditions.

Survey drawings shall be shown at 100% (unscreened) to be screened later if incorporated into design drawings.

5 Drawing Annotation

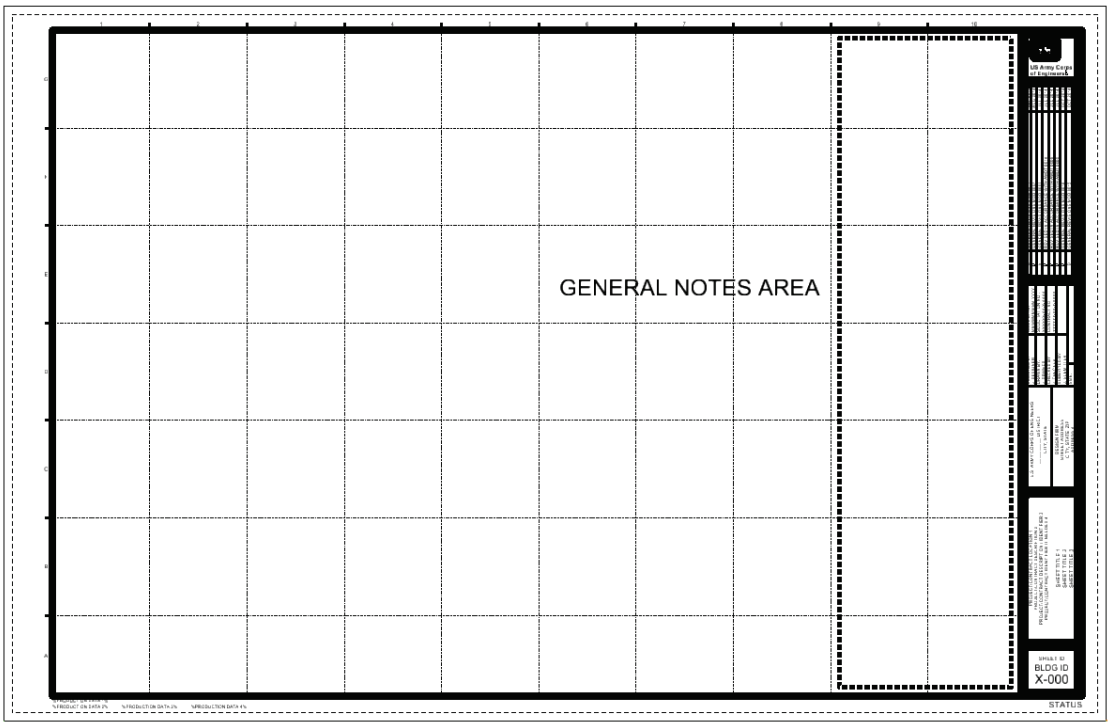
5.1 Text

5.1.1 General notes

Notes on drawings shall be clear and concise. General notes are notes with universal application to contract work on all drawings or to all work on specific drawings. General notes shall be worded such that they are independent of the drawing(s), without cross-referencing or pointing with leader arrows to plans, details, etc. General notes shall be capable of being removed from the drawings and placed in the specifications. General notes that apply to all disciplines shall be located in the General set of sheets and have a sheet title GENERAL NOTES. General notes applicable to sheets for a particular discipline (e.g., architectural, electrical, mechanical) shall be located on the first sheet for that discipline and be titled GENERAL (Insert Discipline) NOTES. General notes applicable to specific sheets shall be worded GENERAL NOTES: THIS SHEET ONLY or GENERAL NOTES: SHEETS _____ THRU _____.

All general notes shall be placed in the far right column(s) of the drawing area of the Sheet File (Figure 5-1). All notes under the GENERAL NOTES heading shall be numbered sequentially starting with 1. General notes shall not include contractual requirements, such as statements of costs, time and place of delivery, methods of payment, and requirements for submission, approval, or distribution of data or reports.

Figure 5-1. Location of General Notes area.



5.1.2 Abbreviations

Abbreviations for words or phrases frequently used in plans, sections, elevations, or details shall follow the abbreviations as established in the NCS UDS Module 5 – Terms and Abbreviations. In addition to this requirement, the following rules regarding abbreviations shall be followed:

- The use of abbreviations shall be kept to a minimum and only when their meanings are unquestionably clear. When in doubt, spell it out.
- Once an abbreviation has been used, the same abbreviation must be continued throughout the project document. Only one abbreviation is allowed for each nomenclature.
- Other abbreviations, particularly discipline-unique abbreviations, may be used but must not conflict with those established in the NCS.
- Any abbreviation used shall be identified in the abbreviations list of the drawing set.
- The rules of grammar concerning capitalization shall be followed. Upper case letters shall be used in all abbreviations except where the use of lower case has been established by the NCS or by long practice.
- Spell out all titles and subtitles.
- The ampersand (&) may be used in firm names (e.g., Jones & Co., Mobile & Ohio R.R.), or in abbreviations of commonly joined words

(e.g., T&G for *tongue and groove*, C&G for *curb and gutter*), but never to take the place of *and* in sentences, notations, or titles.

5.1.3 Capitalization

Capital letters shall be used in text, since capital letters retain readability when reproduced at one-half size (Figure 5-2).

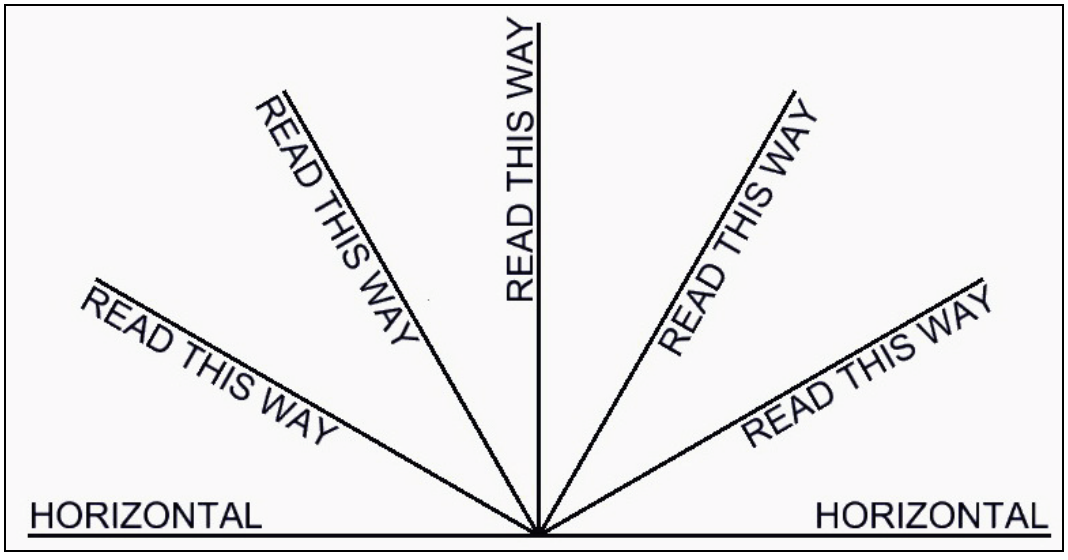
Figure 5-2. Capitalization in text.

5.1.4 Orientation and placement

Text shall be set parallel to the primary base of the drawing. If necessary, text can be rotated at 30-degree angles up to 180 degrees as long as the orientation is as shown in Figure 5-3. However, rotating the text is discouraged to prevent having to turn the drawing sheet to read notations.

Note: *An exception to maintaining this text orientation would be on waterways projects because of the various directions in which channels are located. Often text that has a definite bearing on the contract is kept at proper orientation while map features incidental to the contract are allowed to follow the orientation when created in a north-up base map, which may result in upside-down text on rotated plan sheets.*

Figure 5-3. Orientation of text.



Text shall never be placed over other text. Text shall not be placed over feature lines, hatching, or patterning. If text is required in a hatched or patterned area, the hatching/patterning shall be clipped (masked) so the text can be clearly read.

Text justification depends upon the type of text being placed. For example, general numbered notes shall have upper-left justification, elevation labels appearing to the left of a feature shall have bottom-right justification, and elevation labels appearing to the right of a feature shall have bottom-left justification.

Note: *Use proper planning for text justification, so future editing does not require the text to be moved. Use multiline text (node) vs. single line text wherever multiple lines of text are placed.*

5.1.5 Font

Contrasting text fonts are used within a drawing to delineate types of information. In most A/E/C drawings, the font shown in Table 5-1 and described below should be sufficient.

- Regular font: This font is appropriate for most general notes, labels, dimensions, or title blocks.
- Italic font: An italic font is used where text needs to be easily distinguished from other text.
- Filled font: Filled fonts are used primarily for titles and on cover sheets.
- Symbol font: This font should be used in cases where Greek symbols are representations for technical information.

Table 5-1. Comparison of font types.

Font Type	True Type
Regular	Arial ABCDEFGHIJKLMNOPQRST UVWXYZ
Italic	Arial (Italic) *ABCDEFGHIJKLMNOPQRST* *UVWXYZ*
Filled	Arial (Bold) **ABCDEFGHIJKLMNOPQRST** **UVWXYZ**
Symbol	Arial (Symbols) ΑΒΧΔΕΦΓΗΙϑΚΛΜΝΟΠΘΡΣΤ ΥςΩΞΨΖ αβχδεφγηιφκλμνοπθρστ υϖωξψζ

5.1.6 Text height

The minimum text height for dimensions, notes, callouts, table/schedule text, and general text in plotted CAD files is 3/32 in. (2.4 mm). Title and subtitles shall be plotted equivalent to 3/16 in. (5 mm) and 1/8 in. (3 mm) lettering size, respectively. The text height and text width shall be assigned equal number values. Line spacing shall be equal to one-half of the text height.

Table 5-2 lists recommended text heights for common inch-pound scales, as well as line type scale factors for those scales. Table 5-3 lists recommended text heights for common metric scales.

Note: *The scales shown are not all inclusive. Scales used shall be limited to those commonly found on hand-held architectural, mechanical, and engineering scales. Common scale factors are provided in the A/E/C Workspace through annotation scale. Tables 5-2 and 5-3 are provided as a reference for AutoCAD and legacy drawings.*

Table 5-2. Inch-pound text heights and line type scales.

Scale	Text Height	Line Type Scale
12" = 1' - 0" or Full Size	3/32”	1
6” = 1’-0”	3/16”	2
3" = 1' - 0"	3/8”	4
1-1/2" = 1' - 0"	¾”	8
1" = 1' - 0"	1.125”	12
3/4" = 1' - 0"	1.5"	16
1/2" = 1' - 0"	2.25"	24
3/8" = 1' - 0"	3"	32
1/4" = 1' - 0"	4.5"	48
3/16" = 1' - 0"	6"	64
1/8" = 1' - 0"	9"	96
3/32" = 1' - 0"	12"	128
1/16" = 1' - 0"	18"	192
1/32" = 1' - 0"	36"	384
1" = 5'	5.625”	60
1" = 10'	11.25”	120
1" = 20'	1.875’	240
1" = 30'	2.8125’	360
1" = 40'	3.75’	480
1" = 50'	4.6875’	600
1" = 60'	5.625’	720
1" = 100'	9.375’	1200
1" = 200'	18.75’	2400
1" = 400'	37.5’	4800
1" = 500'	46.875’	6000
1" = 1000'	93.75’	12000
1" = 2000'	187.5’	24000

Table 5-3. Metric text heights and line type scales.

Scale	Text Height	Line Type Scale
1:1 or Full Size	2.4 mm	1
1:2.5	6 mm	2.5
1:5	12 mm	5
1:10	24 mm	10
1:20	48 mm	20
1:30	72 mm	30
1:40	96 mm	40
1:50	120 mm	50
1:60	144 mm	60
1:100	240 mm	100
1:200	480 mm	200
1:400	960 mm	400
1:500	1.2 m	500
1:600	1.44 m	600
1:700	1.68 m	700
1:1000	2.4 m	1000
1:2000	4.8 m	2000
1:5000	12 m	5000
1:6000	14.4 m	6000
1:10000	24 m	10000
1:20000	48 m	20000

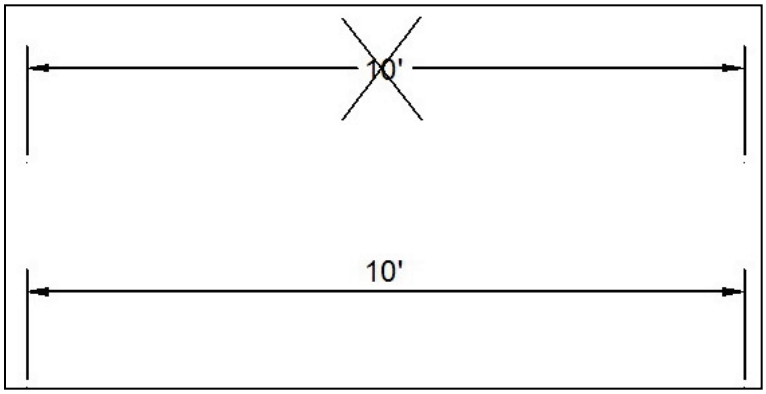
5.2 Dimensions

5.2.1 Dimension placement

Dimension values shall always be placed above the dimension line, preferably midway between the dimension terminators (Figure 5-4). The dimension line shall never be broken to insert the dimension, with the exception of angular dimensioning. It is preferred that dimensions always be placed outside the view, preferably located at the top and/or the right side of the plans. With that in mind, dimensions shall apply to one view only (i.e., no shared dimensions between views). The dimension shall be placed on the view that shows its true length. Exploded dimensions or dimensions where the dimension text has been edited are strongly discouraged except for the following: where software limitations prevent users from providing the appropriate dimensioning, where the dimension

is intended to be an approximation and is notated as such, or where a dimension is displayed as a mathematical formula. An exploded dimension for the sole purpose of displaying a value different from the actual measured value is strictly prohibited.

Figure 5-4. Positioning of text in dimensions.



5.2.2 Graphic settings

Dimensions shall be spaced a minimum of 4 × TH (where TH = dimension text height) from the outlines of the view (shown as dimension "A" in Figure 5-5). Dimension extension lines shall be offset a minimum of 0.5 × TH from the element being dimensioned (dimension "B" in Figure 5-5). Extension lines shall extend 0.5 x TH beyond the dimension line (dimension "C" in Figure 5-5). Parallel dimension lines shall be spaced at least 3 × TH between lines (Figure 5-6). Extension lines that cross other extension lines or dimension lines shall be masked (Reason: if the dimension is dropped or exploded, the dimension will lose its association to the element). The numeral size in dimensions shall match the height of the text in the drawing.

Continuous or staggered dimension lines may be used, depending on convenience and readability; however, continuous dimension lines are preferred.

5.2.3 Dimension terminators

Slashes or filled arrowheads are allowed for dimension terminators. Filled arrowhead terminators shall have an arrowhead width of 1.5 × TH and a height of 0.5 × TH (Figure 5-7).

Figure 5-5. Dimension settings.

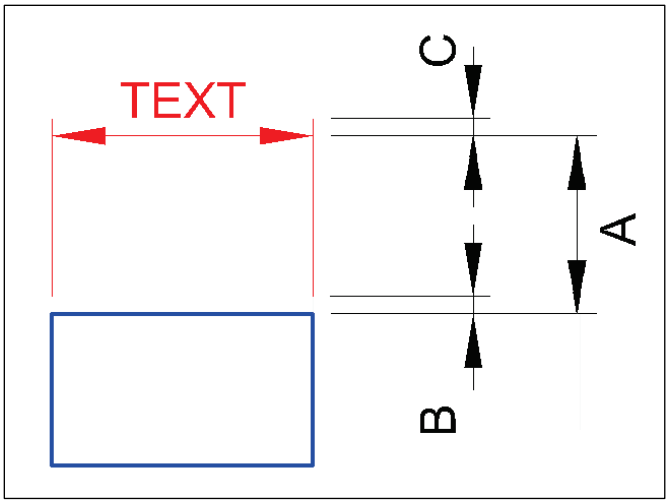


Figure 5-6. Parallel dimension line spacing.

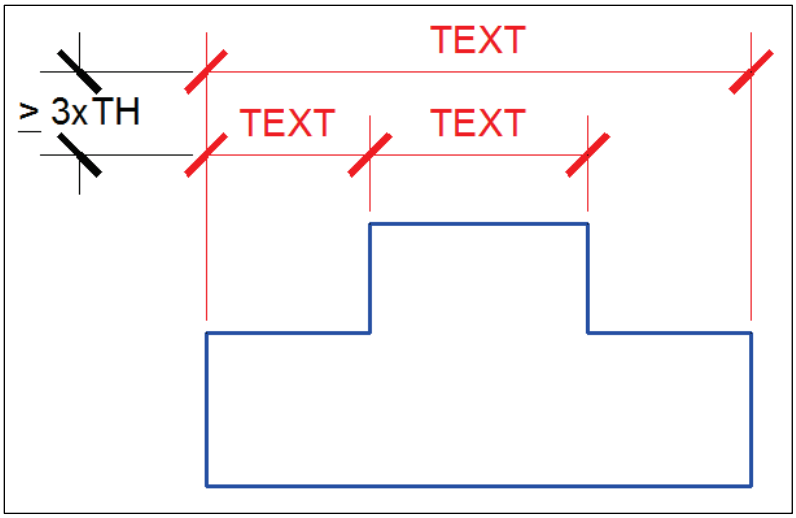
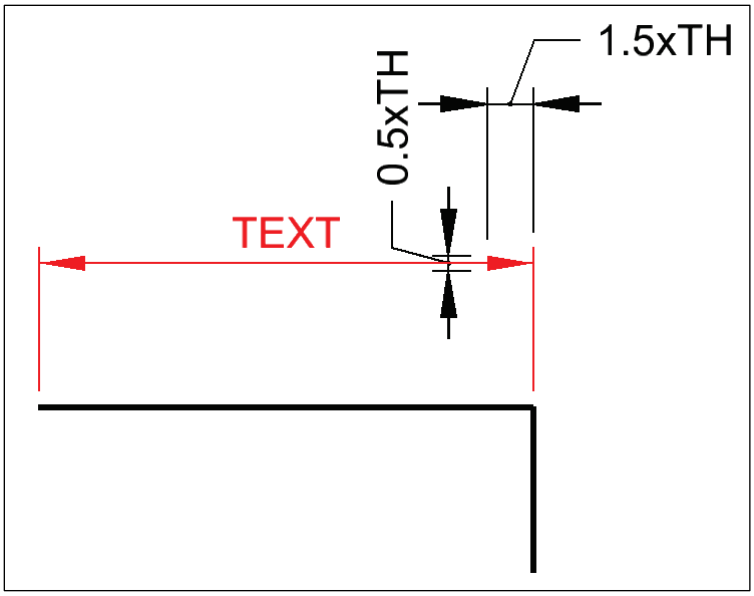


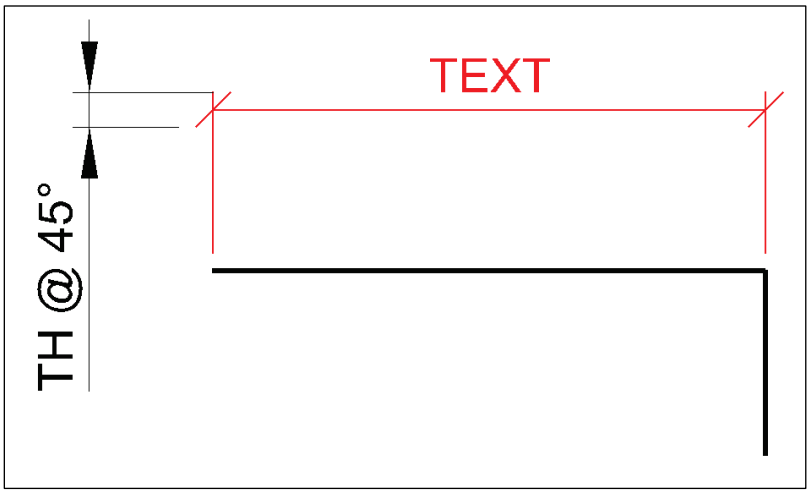
Figure 5-7. Filled arrowhead terminators.



For slash terminators, the slash shall be at an angle of 45 degrees with a height equal to the current text height (Figure 5-8).

Note: *Dimension terminator selection shall be consistent across the entire set of drawings.*

Figure 5-8. Slash terminators.

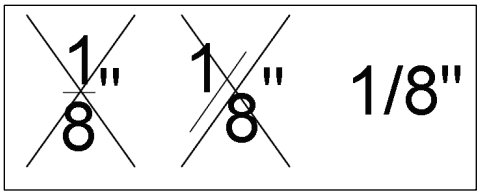


5.2.4 Fractions

All fractions on the drawing shall be inline (not stacked) (Figure 5-9). Fractions shall not be less than 1/16 in. (1.5 mm) because accuracy in the field rarely requires more precision. Decimal values shall always have a

leading zero before the decimal point when values are less than 1. Generally, architectural construction dimensions are shown in feet and inches. Decimals of a foot shall be used where dimensions are being set by surveying equipment, such as beam spacing, foundation locations, and structure widths.

Figure 5-9. Fraction format.



5.2.5 Elevations

Elevations shall be indicated with no more than two decimals (e.g., EL 241.56 or EL 123.00).

5.2.6 Graphic settings

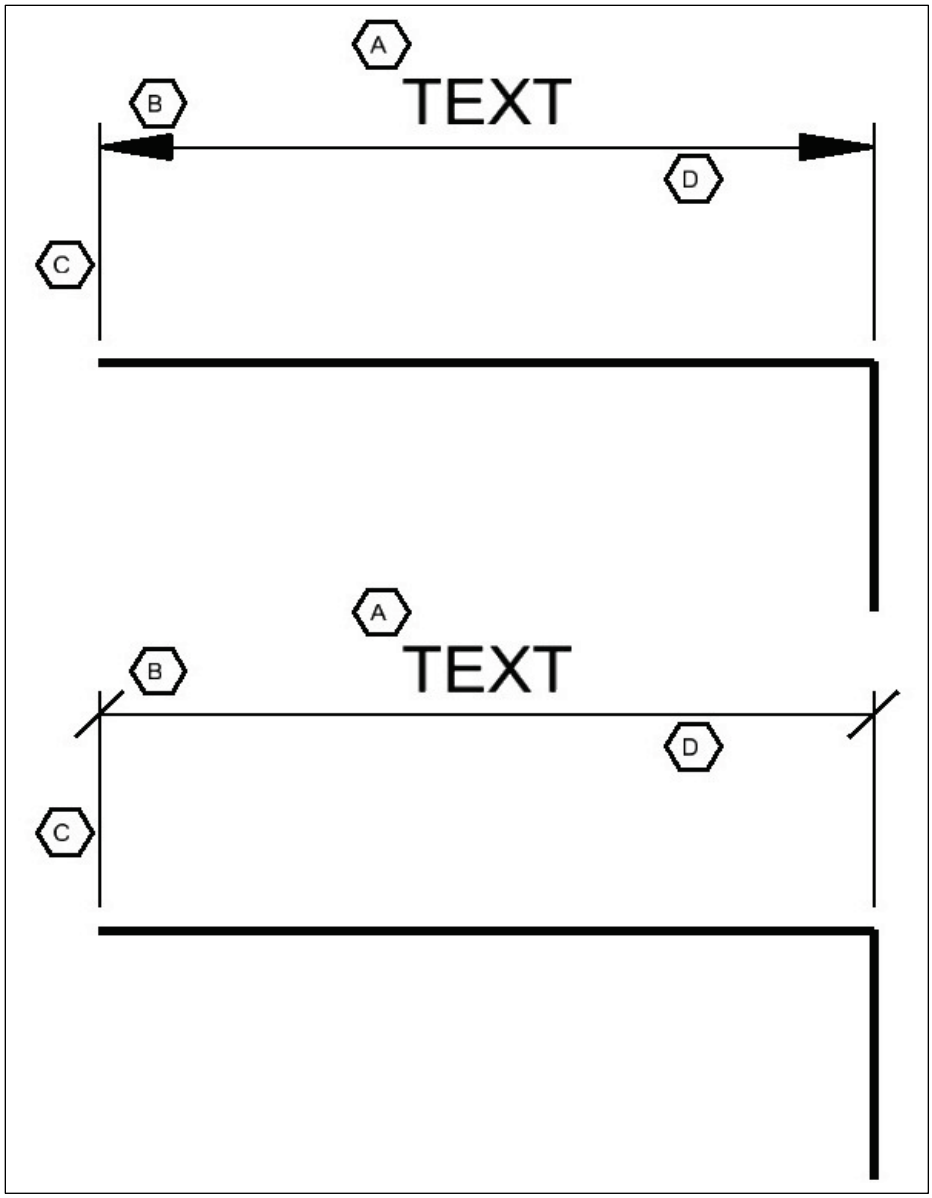
Line width settings for dimensions shall follow those shown in Table 5-4 and Figure 5-10.

Table 5-4. Dimension element settings.

Identifier	Dimension Element	Line Width (mm)
A	Dimension text	N/A*
B	Terminators	0.35
C	Extension lines	0.25
D	Dimension lines	0.25

* Not Applicable for TrueType fonts.

Figure 5-10. Dimension element settings.



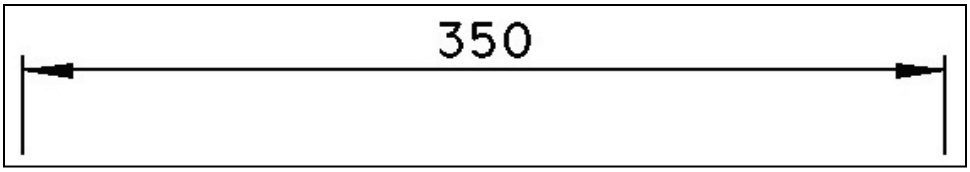
5.2.7 Dimensioning in metric (SI)

Methodologies for dimensioning metric (SI) drawings are based upon the recommendations of the former Construction Metrication Council of NIBS, Washington, DC. These recommendations comply with the American Society for Testing and Materials (ASTM) E 621-94 (ASTM 1999–withdrawn 2008).

5.2.7.1 Millimeters

The preferred unit of measure for most A/E/C vertical/detail work is millimeters. Unit notations are unnecessary and should not be used. The dimension is provided as a whole number as shown in Figure 5-11. Also, a note shall be added to the drawing stating "All dimensions and/or dimensions shown in callouts/notes are in millimeters unless otherwise noted."

Figure 5-11. Dimension in millimeters. Always shown as a whole number.



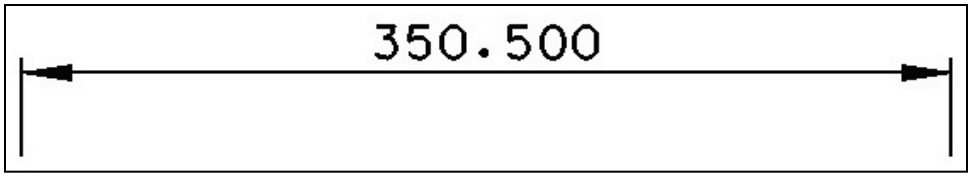
Note: *In circumstances where very small dimensions are used (e.g., machine details), it is permissible to use real numbers for millimeter dimensions. A note shall be placed on the detail regarding this fact.*

5.2.7.2 Meters

For site plans or other drawings rendered to scales over 1:200, the unit of measure is typically meters. Where greater accuracy is required, show dimensions to three decimal places (Figure 5-12). A note shall be added to the drawing stating "All dimensions and/or dimensions shown in callouts/notes are in meters unless otherwise noted."

When meter measurements are included on the same sheet as millimeter measurements, the meter dimension is provided as a real number taken to three places past the decimal point (Figure 5-12). Again, unit notations are unnecessary.

Figure 5-12. Dimension in meters. Always shown as a real number (with decimal).

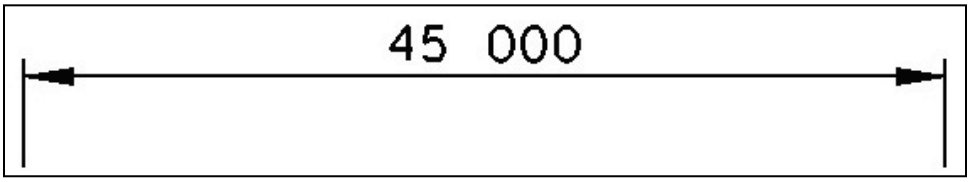


5.2.7.3 Large units of measure

Commas shall not be used when providing large units of measure; instead, a space replaces the traditional comma in numbers containing four or

more digits (e.g., the number 5,000 is displayed as 5 000, the number 45,000 is displayed as 45 000). This method is shown in Figure 5-13.

Figure 5-13. Proper dimension presentations for metric measurements with four or more digits.



Note: *The automatic dimensioning features of AutoCAD do not allow users to replace commas with spaces in dimension text. The dimension text will presently have to be edited to provide the spacing required by ASTM E 621-94 (ASTM 1999).*

5.2.7.4 Dual units

To avoid confusion, dual units (both inch-pound and metric) shall not be used. As stated in Construction Metrication Council (1998), the use of dual units "increases dimensioning time, doubles the chance for errors, makes drawings more confusing, and only postpones the (metric) learning process."

Exceptions to this include certain "standard building designs" where dual dimensions ensure that the design can be used in either SI or inch-pound projects and in situations where products/components used in an SI project are available only as inch-pound products.

6 Schedules

6.1 Features of a schedule

The purpose of a schedule is to relay more detailed information about items shown in the drawing set. At a bare minimum, "a schedule consists of four parts—a subject title (Heading), a column identifying an item (Mark), a column for the description of an item (Item Description), and a column for indicating some notable characteristic (Distinguishing Feature)" (Figure 6-1). While a minimum of three columns is required in a schedule, additional columns are allowed (UDS Module 3 – Schedules (CSI 2014)).

Figure 6-1. Schedule.

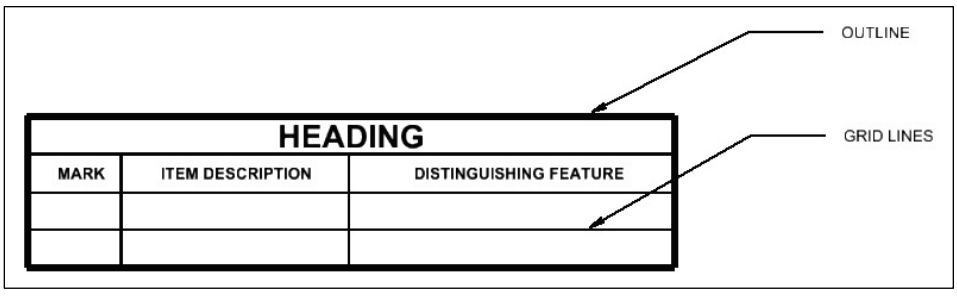
HEADING		
MARK	ITEM DESCRIPTION	DISTINGUISHING FEATURE

6.2 Graphic settings

As far as graphic conventions for schedules, schedule linework shall have the following line widths (Figure 6-2):

- schedule outlines – extra-wide line, 0.70 mm, or Weight 5
- schedule grid lines – medium line, 0.35 mm, or Weight 2.

Figure 6-2. Schedule linework.



It is recommended that headings in a schedule be at least 3/16 in. (5 mm) in height and all other text within the schedule be at least 3/32 in. (2.4 mm) in height.

6.3 Excel schedules

For Excel spreadsheets imported for use as schedules, the following settings shall be followed:

- schedule headings – use Arial with a font size of 19
- schedule text – use Arial with a font size of 10
- use embedded schedules with a scale of 1.

7 Drawing Revisions

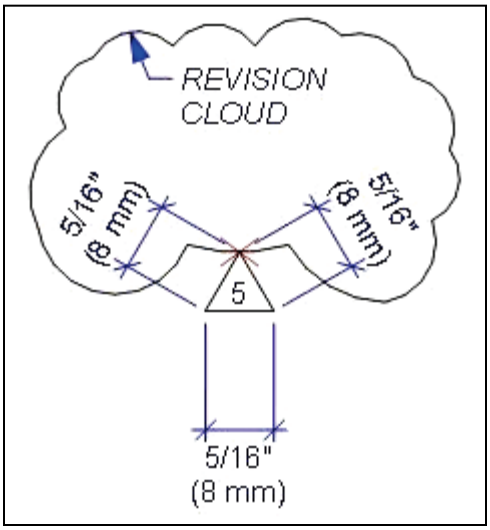
7.1 Revision designations

During development of CAD contract drawings, revisions are inevitable. There are two different designations for these types of revisions—amendments and modifications. Amendments are revisions that occur during the contract advertisement period. Modifications are revisions that are made after the award of a construction contract.

7.2 Revision graphics

All revisions shall be flagged by a revision symbol (Figure 7-1). This symbol shall be an equilateral triangle.

Figure 7-1. Revision symbol.

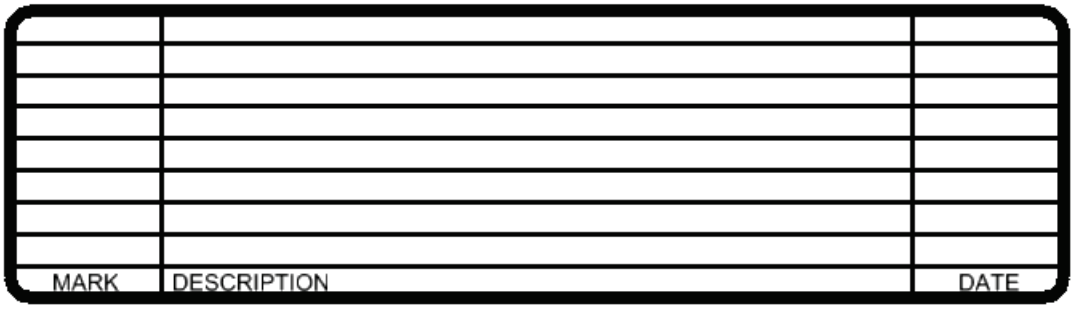


The revision symbol shall be positioned adjacent to the revision. The revision shall be enclosed in a revision cloud drawn at medium thickness (0.35 mm). The revision triangle shall contain sequential numbers for amendments (i.e., 1, 2, 3) or sequential capitalized alphabetical characters for modifications (i.e., A, B, C) per UFC 1-300-09N (Department of Defense 2011).

7.3 Revision (Issue) Block

The Revision (Issue) Block (Figure 7-2) contains a history of revisions to the sheet. It is made up of three fields that contain information about each amendment or modification—MARK, DESCRIPTION, and DATE. All text placed within this block shall be 3/32 in. high.

Figure 7-2. Revision (Issue) Block.



- **MARK**. The MARK column shall contain either a numeric Amendment character (1, 2, 3, etc.) or an upper-case alphabetic Modification character (A, B, C, etc.) per Unified Facilities Criteria 1-300-09N. These characters shall relate to revision symbols (equilateral triangles) with the same corresponding characters found on the sheet. The first Amendment or Modification character shall be placed on the lowest line of the Revision (Issue) Block and subsequent entries shall be made above it.
- **DESCRIPTION**. The DESCRIPTION column shall present brief information related to the Amendment or Modification that directs the reader to more detailed information found in a revision document (e.g., REVISED IN ACCORDANCE WITH AMDT 0004, GENERAL REVISIONS MOD 0006, REVISED TO SHOW AS-BUILT CONDITIONS). The DESCRIPTION column shall not be used to provide lengthy information about the revision. Although not required (or recommended), the initials of the designer who made the revision may be provided beside the Description (e.g., REVISED IN ACCORDANCE WITH AMDT 0001 – WDG).
- **DATE**. The DATE column contains the date (month and year) the revision was released in the change documentation. All dates shall be in the following format: MMM YYYY (e.g., OCT 2014, JUN 2013)

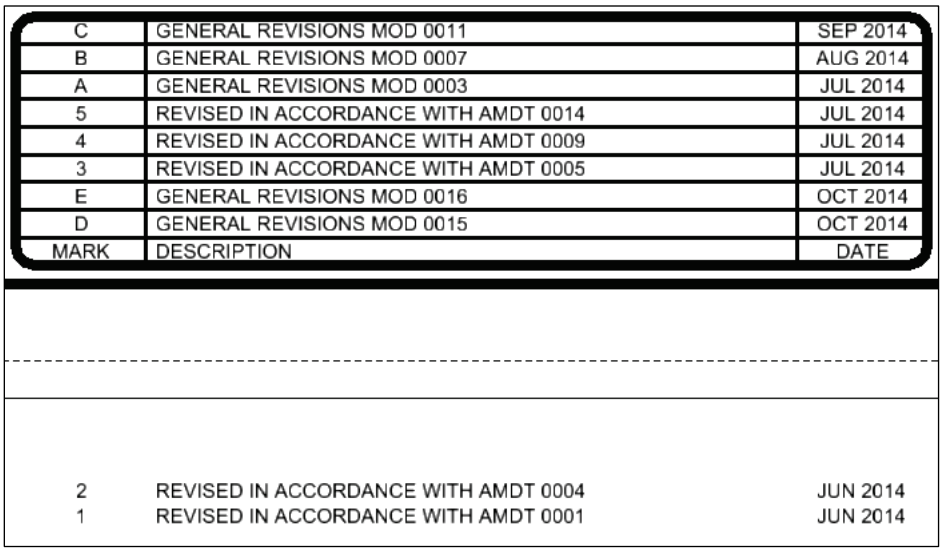
Note: *The APPR. column was removed from the Revision (Issue) Block due to lack of consistency in its use. Currently, there is no consistent*

legal/management direction on how to enforce this field. Initials are text placed in this field using CAD, so there is no method for legal tracking of the data. If showing who approved revisions becomes a requirement, a legal signature (physical or electronic) should be required, as well as direction for consistent usage.

The Revision (Issue) Block provided by the CAD/BIM Technology Center provides eight rows for identifying revisions. However, what if more than eight revision rows are required on a sheet? There are two possible options for dealing with this situation:

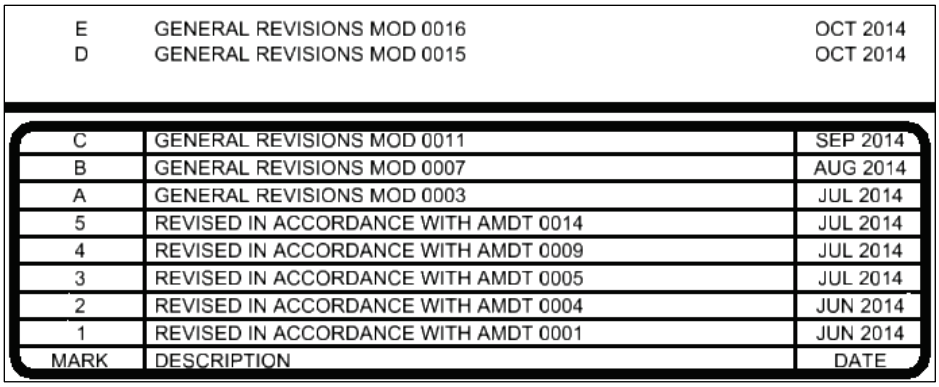
- **Option 1 (Preferred):** Replace the oldest revision in the Revision (Issue) Block with the most current revision and continue replacing revisions as needed (Figure 7-3). If needed, older revisions can be copied outside the plotted area of the sheet for record purposes.

Figure 7-3. Option 1 for showing more than eight revisions.



- **Option 2:** Continue adding revisions directly above the eighth revision row so that they begin to spill out into the Drawing Area (Figure 7-4). This is not the preferred option, as it runs the risk of running into General Notes that may be placed into this section of the Drawing Area.

Figure 7-4. Option 2 for showing more than eight revisions.



E	GENERAL REVISIONS MOD 0016	OCT 2014
D	GENERAL REVISIONS MOD 0015	OCT 2014

MARK	DESCRIPTION	DATE
C	GENERAL REVISIONS MOD 0011	SEP 2014
B	GENERAL REVISIONS MOD 0007	AUG 2014
A	GENERAL REVISIONS MOD 0003	JUL 2014
5	REVISED IN ACCORDANCE WITH AMDT 0014	JUL 2014
4	REVISED IN ACCORDANCE WITH AMDT 0009	JUL 2014
3	REVISED IN ACCORDANCE WITH AMDT 0005	JUL 2014
2	REVISED IN ACCORDANCE WITH AMDT 0004	JUN 2014
1	REVISED IN ACCORDANCE WITH AMDT 0001	JUN 2014

References

American Society for Testing and Materials. 1999 (withdrawn 2008). *Standard practice for the use of metric (SI) units in building design and construction (Committee E-6 Supplement to E380)*. ASTM E 621-94. Philadelphia, PA.

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14. ABSTRACT

The A/E/C Graphics Standard has been developed by the CAD/BIM Technology Center to document how proper hand-drafting practices can be achieved in Building Information Modeling (BIM), Civil Information Modeling (CIM), and Computer-Aided Design (CAD). It is through the collection and documentation of these practices that consistent models and drawings shall be achieved throughout the U.S. Army Corps of Engineers (USACE), as well as other federal agencies. In the collection of these practices, various historical USACE District drafting manuals were consulted and compared against practices contained in various industry and national standards. The documentation of these practices will help to achieve both clear and aesthetically pleasing construction documents.

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