Engineering Drawing & CAD Standards

Mechanical Design/CAD Program

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The information contained in this departmental standard supersedes the ASME standards listed below:

ANSI/ASME Y14.2M-1992 (R2003)   *Line Conventions and Lettering*

ANSI/ASME Y14.3-2003   *Multi and Sectional View Drawing*

ANSI/ASME Y14.34M-1996   *Parts Lists, Data Lists, and Index Lists*

ANSI/ASME Y14.36M-1996 (R2002)   *Surface Texture Symbols – Metric Version*

ANSI/ASME Y14.35M-1997 (R2003)   *Revision of Engineering Drawing and Associated Documents*

ANSI/ASME Y14.38-1999   *Abbreviations and Acronyms*

ANSI/ASME Y14.5-2009   *Dimensioning and Tolerancing*

ANSI/ASME Y14.6-2001 (R2007)   *Screw Thread Representation, Engineering Drawing, and Related Documentation Practice*

ANSI/ASME Y14.6AM-2001 (R2007)   *Screw Thread Representations (Metric Supplement)*

I. LINE CONVENTIONS

A. The lines shown in Figure 1.1 are to be used in all mechanical drawings. The corresponding AutoCAD linetype and lineweight are given next to each linetype.

VISIBLE OBJECT LINES	————————	THICK 0.6mm CONTINUOUS LINETYPE
HIDDEN LINES	– – – – – – – – –	THIN 0.3mm HIDDEN LINETYPE
SECTION LINES	————————	THIN 0.3mm CONTINUOUS LINETYPE
CENTERLINES	— – —— – — – ——	THIN 0.3mm CENTER LINETYPE
DIMENSION LINES EXTENSION LINES	————————	THIN 0.3mm CONTINUOUS LINETYPE
CUTTING–PLANE LINES	——— – ——— – ———	THICK 0.6mm PHANTOM LINETYPE
	—— —— —— ——	THICK 0.6mm HIDDENX2 LINETYPE
BREAK LINES	〜〜〜〜	THICK 0.6mm VISIBLE LINETYPE
	———∿———∿———∿———	THIN 0.3mm CUSTOM LINETYPE
PHANTOM LINES	—— – – —— – – ——	THIN 0.3mm PHANTOM LINETYPE
CHAIN LINES	—— – —— – —— – ——	THICK 0.6mm CENTER LINETYPE

FIGURE 1.1: STANDARD LINESTYPES AND LINEWEIGHTS.

B. The AutoCAD linetype scale (LTSCALE) for mechanical drawings plotted at a scale of 1:1 shall be set according to the table shown below:

System of Measurement	LTSCALE	Drawing scale
Decimal-inch	0.5	1:1
Metric	12	1:1

C. The linetype scale shall be modified proportionally for drawings plotted at scales other than 1:1. For example, if the drawing scale is 1:2 for a metric drawing, the LTSCALE shall be set to 6 (=12 x ½).

CENTER LINES

D. The center mark size dimension variable in AutoCAD shall be .09" (2 mm).

E. The center mark shall extend .09" (2 mm) beyond the edges of circular features (see Figure 1.2).

F. A center line representing the longitudinal axis of a cylindrical or rectangular feature shall extend .312" (8 mm) beyond the boundary of the feature (see Figure 1.2).
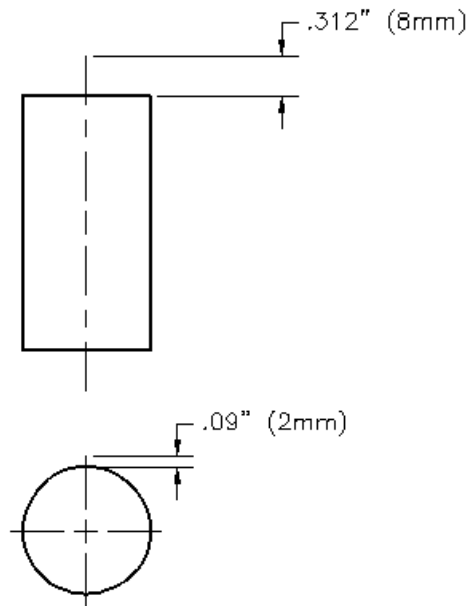
FIGURE 1.2: CENTERLINE EXTENSIONS.

G. A center line shall not be lengthened to create the small dash when the center line is too short to show a single small dash.

H. When a center line and visible or hidden line are coincident, the center line shall end before the visible line or hidden line and there shall be a .09" (2 mm) gap between the end of the center line and the beginning of the visible line (see Fig. 1.3 and 1.4).
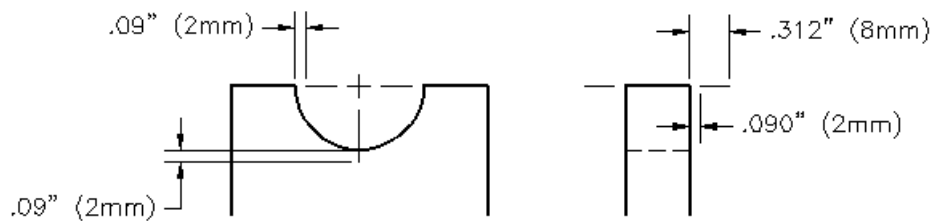
FIGURE 1.3: CENTERLINES COINCIDENT WITH VISIBLE LINES.

I.   If center lines are required for features arranged in a radial pattern, the center lines shall be oriented radially but shall not intersect at the center of the pattern (see Figure 1.4). Note that the centerline bolt circle may not have the small dashes oriented at the centers of the pattern of features.
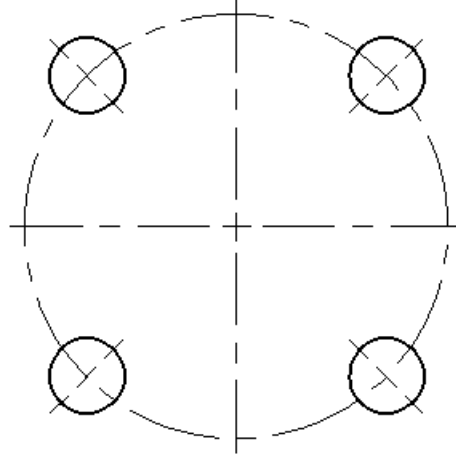
FIGURE 1.4: CENTERLINES IN RADIAL PATTERNS.

J.   Center lines of features arranged in a rectangular pattern shall be extended so that the pattern is continuous (see Figure 1.5). Note that the center marks for the rounded corners are extended .09" (2 mm) beyond the edge of the part.
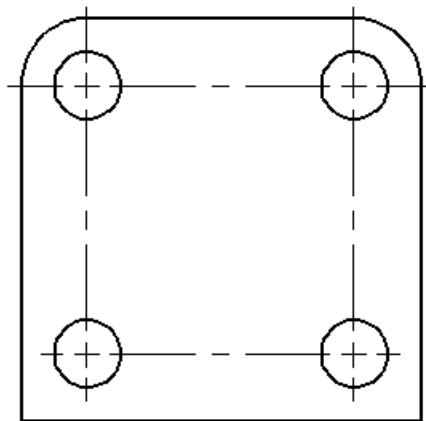
FIGURE 1.5: CENTERLINES IN RECTANGULAR PATTERN.

K. Where center marks are used in semi-circular features, the center mark shall only extend through the circular feature edge (see Figure 1.6).
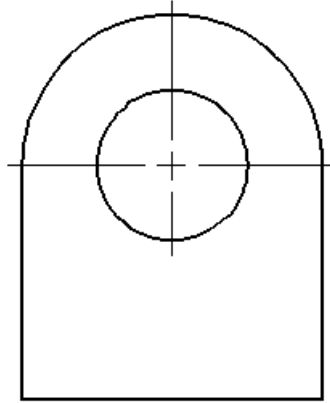
FIGURE 1.6: CENTER MARKS THROUGH SEMI-CIRCULAR FEATURES.

L. Center lines may be used to indicate planes of symmetry. In such cases, the center lines shall extend .312" (8 mm) beyond the edges of the symmetrical feature (see Figure 1.7). Center lines used as lines of symmetry do not require symmetry marks.
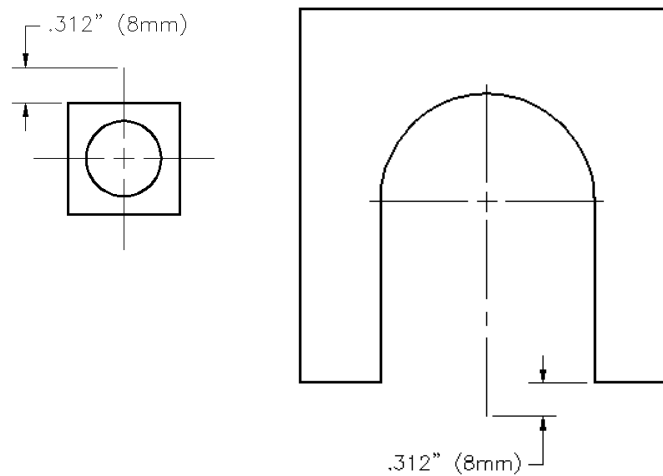
FIGURE 1.7: CENTERLINES FOR SYMMETRICAL FEATURES.

II. DRAWING CONVENTIONS

AUXILIARY VIEWS

A. Auxiliary views shall be connected to the adjacent view from which they are developed by a single center line or an extension line connecting identical external edges of the part. The centerline shall go through the same feature in both views. The extension line shall have a gap between the visible edge of the part and the extension line equal to .09" (2 mm) (see Figure 2.1).
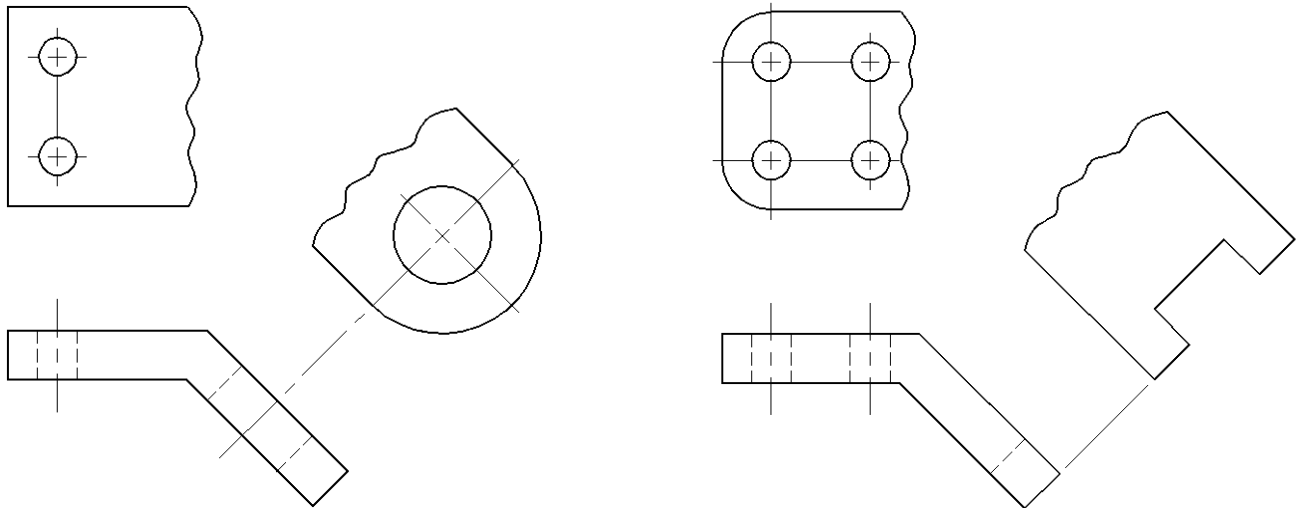
FIGURE 2.1: AUXILIARY VIEWS.

B. The break line on all partial auxiliary views shall be smooth curve (see Figure 2.1).

C. Hidden lines shall be omitted on features when they appear foreshortened in orthographic views.

PARTIAL VIEWS

D. The break line on all partial views shall be created with a smooth curve (see Fig. 2.1).

SECTION VIEWS

E. The break line on all broken-out section views shall be created with a smooth curve (See Fig. 1.1).

F. The plotted arrowhead size on the cutting-plane line shall be .25" (6 mm), two times (2x) the size of the dimension arrow.

G. Cutting-plane lines shall be drawn with thick phantom lines (lineweight = 0.6 mm) (See Fig. 1.1).

H.   When a cutting-plane line is coincident with a visible, hidden, or center line, the cutting-plane line shall take precedence.

I.   The cutting-plane line shall extend .50" (12 mm) from the edge of the object and extend at right angles .50" (12 mm) from the extension (see Fig. 2.2).
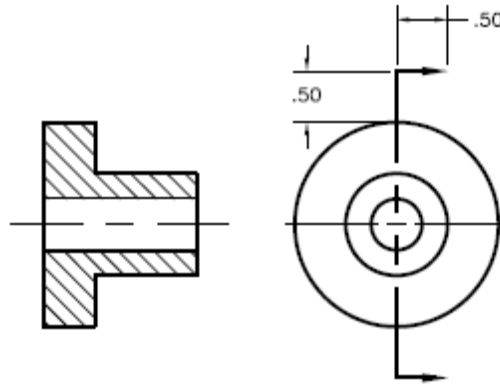
FIGURE 2.2: CUTTING PLANE LINES.

CONVENTIONAL BREAKS

J.   Solid cylinders may be broken into shorter segments in a drawing. When the solid cylinder is broken, the ends shall be shown with a conventional shaft break. The dimensions for drawing the shaft break are shown in Fig. 2.3.
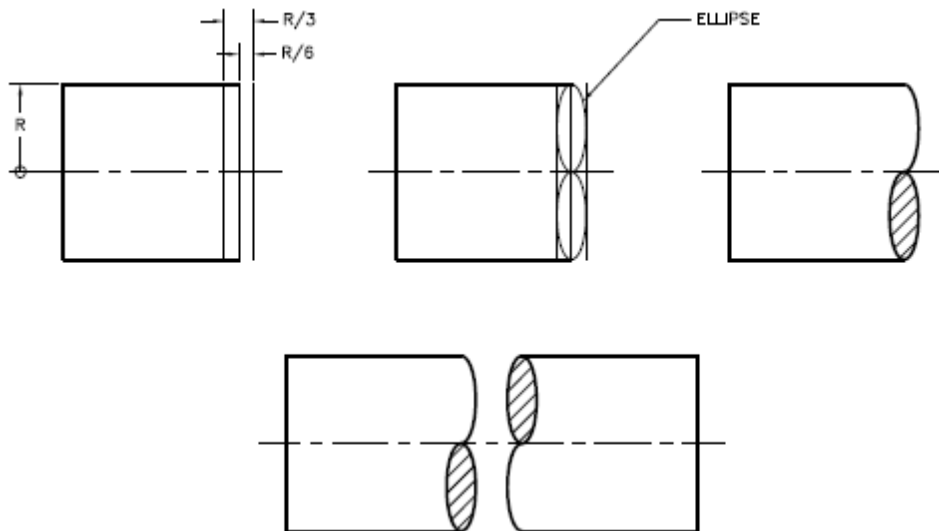
FIGURE 2.3: SHAFT BREAK CONSTRUCTION.

J.   The dimension for the overall length of the broken cylinder shall be underlined to clearly indicate that it is not drawn to scale.

DEVELOPMENTS

J.   Developed views shall show quadrants with thin solid lines.

K.   Sheet metal developments shall show the center line of the bends with centerlines which extend beyond the edges of the object .312" (8 mm).

III.   DIMENSION CONVENTIONS

DIMENSION APPEARANCE

A.   There shall be no gap between extension lines and center lines.

B.   Drawings in decimal-inch units shall use the ROMANS AutoCAD font for all drawing text. Metric drawings shall use the ISOCP AutoCAD font.

C.   The plotted size of text (including dimensions) shall be .125" (3 mm). All tolerances shall be drawn at full text height.

D.   All drawing text shall have a thin lineweight (lineweight = 0.3 mm).

E.   Dimensions and drawing notes shall specify decimal numbers and not fractions. All fractions shall be converted to decimals with the appropriate decimal places according to the tolerance specifications.

F.   If an extension line crosses an arrowhead the extension line shall be broken around the arrowhead.

G.   When more than one diameter is dimensioned in a single note always point to the outside (larger) circle.

H.   A leader line shall end with the same style and size arrowhead as used with dimension lines. The leader line shall be oriented close to 45°, but between 30° and 60°, and not horizontal or vertical.

I.   When inch dimensions are shown in a millimeter drawing the abbreviation "IN" shall follow the inch value. When millimeter dimensions are shown in an inch drawing the abbreviation "mm" shall follow the millimeter value.

J.   When dimensioning with dual dimensions, square brackets shall be used around the second unit value.

K. When a dimension needs to locate an intersection or bend, extension lines are drawn in the profile view as shown in Fig. 2.3. The extended intersection lines are drawn on a thin layer. The lines shall be offset from the object lines by .09" (2 mm) and cross by .09" (2 mm).
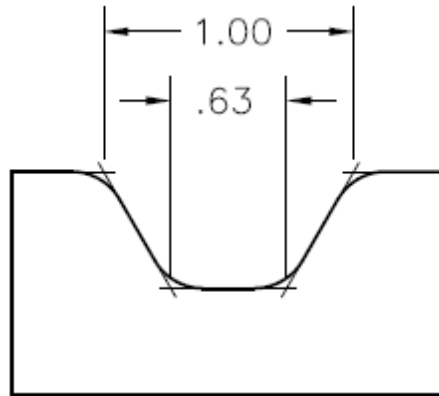
FIGURE 3.1: EXTENDED INTERSECTIONS.

L. Symbols are preferred over the corresponding complete word or abbreviation in dimensions and drawing notes. The symbols are shown in Figure 3.2. Dimensions for symbols shown are as plotted. The dimension variable, h, represents the plotted dimension text height. For decimal-inch drawings h=.125", and for metric drawings h=3 mm.

M. Symbols shall be selected from the GDT font in AutoCAD. If the standard symbol shown in Fig. 3.2 does not exist in the GDT font, then it shall be created according to the dimensions given in Fig. 3.2.

N. Where no symbol exists, standard abbreviations are preferred over complete words.
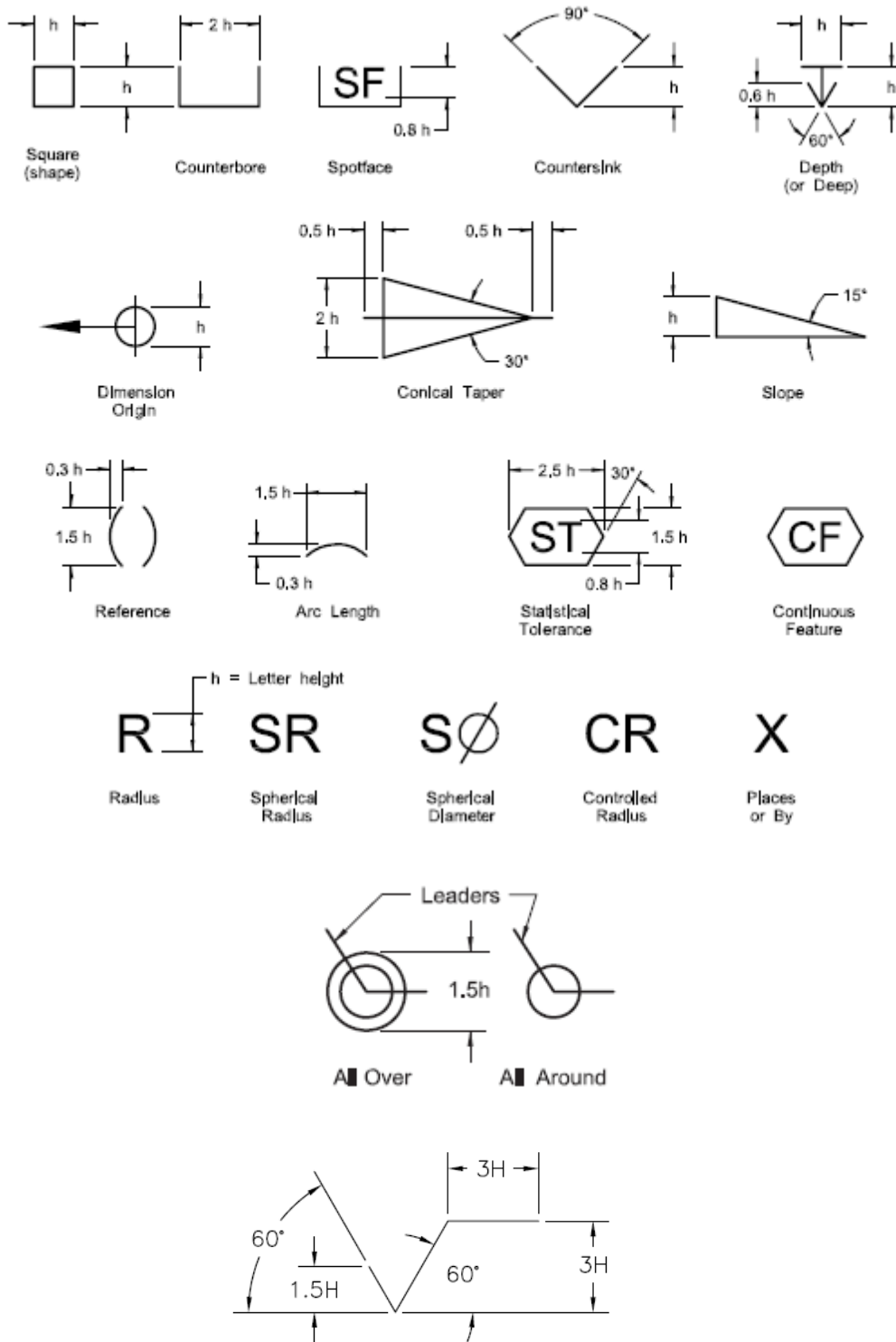
Figure 3.2: DIMENSION SYMBOLS.

O. A surface texture symbol with text or numbers shall be oriented horizontally. Surface texture symbols without text or numbers shall be oriented at any angle. Surface texture symbols shall be placed on the outside of the part geometry.

DIMENSIONING PROCEDURE

P. All drawing text shall be placed in Paper Space.

Q. To convert from inches to millimeters multiply the inch value by 25.4 to find the corresponding value in millimeters. To convert from millimeters to inches multiply the inch value by .03937 to find the corresponding value in inches.

R. Conversion from fractional-inch to decimal-inch units shall take into account the full number of decimal places. The number of decimal places shown in the dimension shall be truncated according to the required tolerance level.

Example:

Original dimension: 3-1/64”
Convert to decimal format: 3.015625”
Dimension tolerance: ±.001
Converted dimension: 3.015±.001

DIMENSION NOTES

S. Drawing text shall be displayed in all capital letters.

T. All drawing notes shall be placed on the NOTES layer.

U. General drawing notes shall be placed to the left of the title block.

V. The format for general notes shall be as shown below. The number for each line shall be aligned under the heading.

NOTES:
1. **FIRST NOTE**
2. **SECOND NOTE**
3. **THIRD NOTE**

P. The following are drawing notes which shall be shown on all mechanical drawings:

DRAWING IN ACCORDANCE WITH ASME Y14.5-2009.
ALL DIMENSIONS IN INCHES (or **MILLIMETERS**)**.**

Q. The following are examples of drawing notes which are to be included in the drawing according to need. Notes must be modified according to the specification of the drawing.

ALL FILLETS AND ROUNDS R(x) **UNLESS OTHERWISE SPECIFIED.**
REMOVE ALL BURRS AND SHARP EDGES.
FINISH ALL OVER.
CHAMFER BOTH ENDS (x) **X** (x)°
ALL DIMENSIONS BASIC UNLESS OTHERWISE SPECIFIED.
ALL UNTOLERANCED DIMENSIONS ±(x)
ALL THREADS IN ACCORDANCE WITH ASME B1.13M-2001. (for Metric M profile threads only)**.**
ALL THREADS IN ACCORDANCE WITH ASME B1.1-2003. (for Unified inch screw threads only)**.**
SURFACE TEXTURE IN ACCORDANCE WITH ASME Y14.36-1996 (R2002).
SURFACE TEXTURE UNITS IN µM (or **µIN**).

ALL SURFACES TO BE $\overset{\displaystyle 3.2}{\bigvee}$ **UNLESS OTHERWISE SPECIFIED.** (modify roughness value as needed)

SURFACES MARKED $\bigvee$ **TO BE** $\overset{\displaystyle 3.2}{\bigvee}$ **UNLESS OTHERWISE SPECIFIED.** (modify roughness value as needed).

W. Common standard abbreviations are shown in the following table.

Assembly	ASSY	Fillister	FIL	Pitch circle	PC
Auxiliary	AUX	Finish all over	FAO	Pitch diameter	PD
Backface	BF	Flat head	FLH	Point	PT
Bearing	BRG	Flat point	FP	Pratt & Whitney	PW
Between centers	BC	Gage	GA	Quadrant	QDRNT
Bolt circle	BC	Head	HD	Quarter	QTR
Both faces	BF	Headless	HDLS	Radial	RDL
Both sides	BS	Hexagonal	HEX	Radius	R
Brass	BRS	Inch	IN	Rectangle	RECT
Bronze	BRZ	Inside diameter	ID	Reference line	REFL
Cap screw	CAP SCR	Keyseat	KST	Relief	RLF
Cast iron	CI	Keyway	KWY	Required	REQD
Cast steel	CS	Left hand	LH	Right hand	RH
Casting	CSTG	Length	LG	Root mean square	RMS
Center	CTR	Lockwasher	LKWASH	Round	RND
Center line	CL	Long	LG	Screw	SCR
Center to center	C TO C	Machine screw	MSCR	Section	SECT
Chamfer	CHAM	Malleable iron	MI	Set screw	SSCR
Circular	CIR	Material	MATL	Sheet	SH
Clearance	CL	Maximum	MAX	Single	SGL
Clockwise	CW	Micrometer	µm	Slotted	SLTD
Counterbore	CBORE	Millimeter	mm	Socket	SKT
Countersink	CSK	Minimum	MIN	Socket head	SCH
Counterclockwise	CCW	Multiple	MULT	Square	SQ
Decimal	DEC	Number	NO	Standard	STD
Deep/Depth	DP	On center	OC	Steel	STL
Dimension	DIM	Outside diameter	OD	Surface	SURF
Distance	DIST	Outside face	OF	Thick	THK
Double	DBL	Overall	OA	Thread	THD
Equal	EQL	Part	PT	Through	THRU
Equally spaced	EQLSP	Perpendicular	PERP	Washer	WSHR
Fastener	FSTNR	Pitch	P	Woodruff	WDF
Fillet	FIL			Worm gear	WMGR

PREFERRED SIZES

K. The preferred basic sizes for computing tolerances in metric units are given in table below. All sizes are in millimeters.

First Choice	Second Choice	First Choice	Second Choice	First Choice	Second Choice
1		10		100	
	1.1		11		110
1.2		12		120	
	1.4		14		140
1.6		16		160	
	1.8		18		180
2		20		200	
	2.2		22		220
2.5		25		250	
	2.8		28		280
3		30		300	
	3.5		35		350
4		40		400	
	4.5		45		450
5		50		500	
	5.5		55		550
6		60		600	
	7		70		700
8		80		800	
	9		90		900
				1000	

L. The preferred basic sizes for computing tolerances in decimal-inch units are given in two tables below. When specifying fits, the basic size of mating parts shall be chosen from the decimal series or the fractional series.

Decimal Series (in.)					
.010	.16	2.00	4.60	8.50	14.50
.012	.20	2.20	4.80	9.00	15.00
.016	.24	2.60	5.00	9.50	15.50
.020	.30	2.80	5.20	10.00	16.00
.025	.40	3.00	5.40	10.50	16.50
.032	.50	3.20	5.60	11.00	17.00
.040	.60	3.40	5.80	11.50	17.50
.05	.80	3.60	6.00	12.00	18.00
.06	1.00	3.80	6.50	12.50	18.50
.08	1.20	4.00	7.00	13.00	19.00
.10	1.40	4.20	7.50	13.50	19.50
.12	1.60	4.40	8.00	14.00	20.00
	1.80				

Fractional Series (in.)					
.015625	.5000	2.2500	5.0000	9.5000	15.0000
.03125	.5625	2.5000	5.2500	10.0000	15.5000
.0625	.6250	2.7500	5.5000	10.5000	16.0000
.09375	.6875	3.0000	5.7500	11.0000	16.5000
.1250	.7500	3.2500	6.0000	11.5000	17.0000
.15625	.8750	3.5000	6.5000	12.0000	17.5000
.1875	1.0000	3.7500	7.0000	12.5000	18.0000
.2500	1.2500	4.0000	7.5000	13.0000	18.5000
.3125	1.5000	4.2500	8.0000	13.5000	19.0000
.3750	1.7500	4.5000	8.5000	14.0000	19.5000
.4375	2.0000	4.7500	9.0000	14.5000	20.0000

IV.   THREAD AND FASTENER REPRESENTATION

A.   The arrowhead from the leader of a thread note shall be attached to the outer (hidden line) circle of a tapped (threaded) hole (see Figure 4.1).
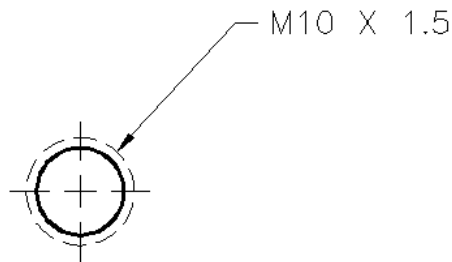

FIGURE 4.1: THREAD NOTATION LEADER.

B.   Decimal values shall be used in all thread notation. Fractional values shall be converted decimals with the appropriate number of decimal places based on tolerance requirements.

C.   Drill numbers shall not be specified in the thread notation. The drill number shall be converted to the corresponding decimal size.

D.   Unless specified otherwise, threads shall be drawn with the simplified representation.

E.   Threads drawn with the schematic representation shall show the crest and root lines with a thin lineweight, as shown in Fig. 4.2. The end of the threads shall be drawn with a thick lineweight.

F.   The radial distance, in inches and millimeters, between the major and minor diameters in a thread drawing, referred to as the depth, D (as shown in Fig. 4.2), shall be drawn according to the tables shown below.

G.   The axial distance, in inches and millimeters, between the major and minor diameters in a thread drawing, referred to as the pitch, P (as shown in Fig. 4.2), shall be drawn according to the tables shown below.

Thread Depth and Pitch Tables (inches)

Major Diameter	#5 (.125) to #12 (.216)	.25	.3125	.375	.4375	.5	.5625	.625	.6875	.75	.8125	.875	.9375	1
DEPTH, D	.03	.03	.03	.04	.04	.06	.06	.06	.06	.08	.09	.09	.09	.09
PITCH, P	.04	.06	.06	.06	.06	.09	.09	.09	.09	.12	.12	.12	.12	.12

Thread Depth and Pitch Tables (millimeters)

Major Diameter	6	8	10	12	14	16	18	20	22	24
DEPTH, D	0.8	0.8	1.2	1.2	1.6	1.6	1.6	2	2.4	2.4
PITCH, P	1.6	1.6	2	2	2.4	2.4	2.4	2.4	2.4	2.4

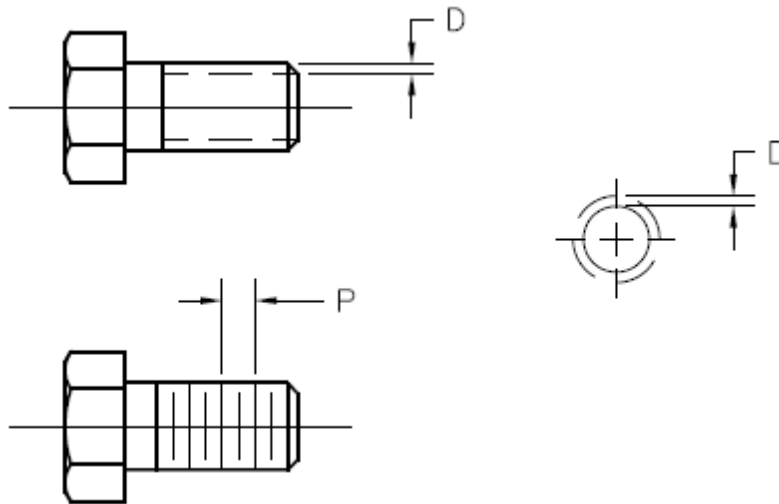
FIGURE 4.2: THREAD DEPTH AND PITCH.

H.   External threads drawn in simplified representation shall extend to the end of the chamfer, as shown in Fig. 4.3.
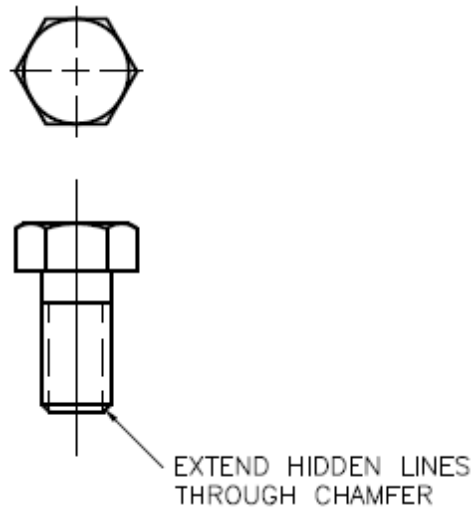
EXTEND HIDDEN LINES
THROUGH CHAMFER

FIGURE 4.3: THREAD CHAMFER.

I.   Thread lengths for bolts or screws up to 6" (150 mm) long shall be calculated using the following formula

THREAD LENGTH = 2D + .25" (or 6 mm)

J.   Thread lengths for bolts over 6" (150 mm) long shall be calculated using the following formula

THREAD LENGTH = 2D + .50" (or 12 mm)

K.   Fasteners too short for the above formulas shall be threaded 3 pitches from the head.

L.   Machine screws shall not have a chamfer drawn at the end of the fastener.

M.   Tapped holes shown in section shall be drawn such that the line dividing the threads from the hole is a thick (0.6 mm) solid line, as shown in Fig. 4.4.

N.   When threaded fasteners are shown in assembly, the lines representing the minor diameter shall not be shown after the end of the fastener, as shown in Fig. 4.4.
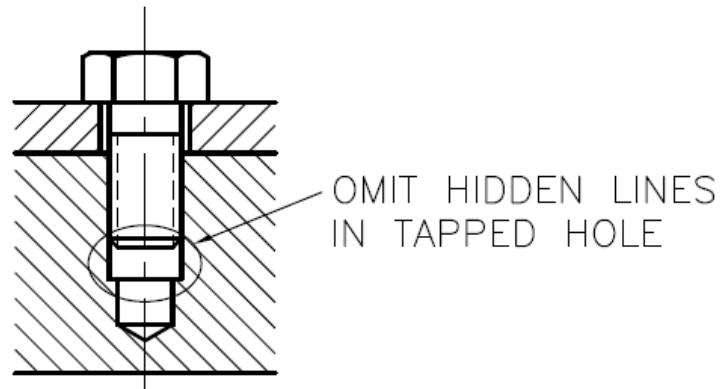
FIGURE 4.4: HIDDEN LINES VISIBLE IN THREADED ASSEMBLY.

O.   All orthographic views of hex head bolts, screws, and hex nuts in profile shall show three faces, as shown in Fig. 4.5.
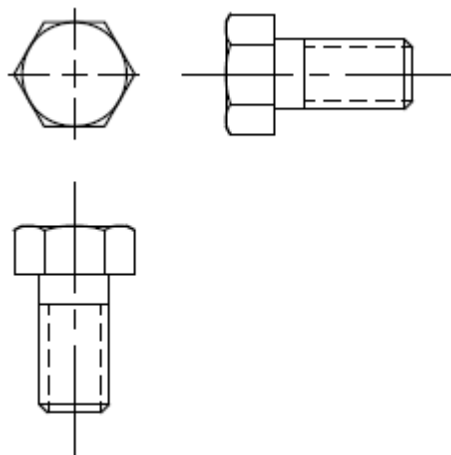

FIGURE 4.5: THREE FACES OF HEX HEAD IN PROFILE.

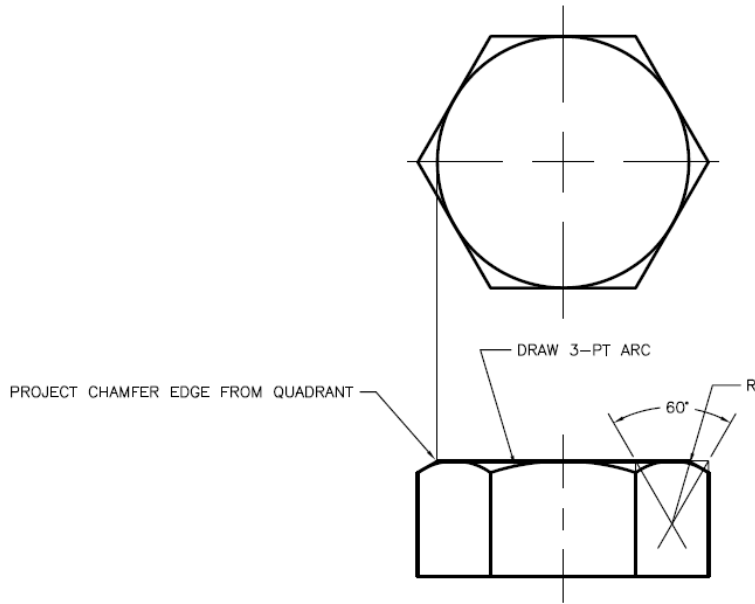P.   The construction of hex head bolts and nuts is shown in Fig. 4.6.

DRAW 3-PT ARC

PROJECT CHAMFER EDGE FROM QUADRANT

60°

R

FIGURE 4.6: HEX HEAD BOLT AND NUT CONSTRUCTION.

V. TABLES

BILL OF MATERIALS

A. The bill of material table shall be attached to the top of the title block.

B. The bill of material table shall show part numbers in increasing order from bottom to top.

C. The bill of material table format shall consist of, from left to right: item number, quantity, part name, part description.

D. Text in the bill of material shall be placed on a layer with thin continuous lines.

E. The description in the bill of material for a non-standard part shall be the drawing number corresponding to the detail drawing of the part. Standard parts shall be described with a manufacturer name and catalog number or common description.

F. The parts called out in an assembly drawing with balloons shall be identified with numbers. The font shall be the same as used in the dimension text. The part numbers shall be centered horizontally and vertically in the balloons. The plotted text size and balloon diameter shall vary according to the drawing paper size (see table below).

Paper Size		Balloon Diameter	Text Size
Inch	ISO		
A	A4	11 mm (.44")	3 mm (.125")
B	A3		
C and larger	A2 and larger	13 mm (.50")	5 mm (.19")

G. The balloons, leaders, and part numbers in the balloons shall be placed on a layer with thin continuous lines.

H. The bill of material, balloons, leaders, and all related text shall be placed in Paper Space.

I. Balloons shall be attached to leaders radially. Balloons shall not have landings.

REVISION TABLES

J. The revision table shall be fixed in the top right corner of the drawing border. It shall be visible at all times.

K. The revision table shall show revision numbers in increasing order from top to bottom.

L. The revision table format shall consist of, from left to right: zone, revision, description, date, approved.

M. Revisions will be identified on the drawing with an equilateral triangle with 13 mm (.50") sides. Each revision triangle will have a capital letter corresponding to the specific revision identified in the revision table. The height of the revision letter in the triangle revision letter shall be 3 mm (.125"). The letter shall be middle-center justified in the triangle.

N. Revision identifiers and associated text shall be placed on a layer with thin continuous lines.

O. Revision identifiers shall be drawn in Paper Space.

P. The description of the revision shall include the previous value and the new value.

Q. Revision identifiers shall be placed adjacent to the feature or dimension being revised.

R. If applicable, revision identifiers may be connected at their base vertex.

VI. DRAWING MEDIA

A. All mechanical drawings shall be plotted using the ANSI (inch) paper sizes. ISO (metric) paper sizes will not print on the CAD Dept. printers. All metric drawings shall be printed on the equivalent ANSI-size paper. The paper conversion table is shown below.

ISO Paper Size	Equivalent ANSI Paper Size	Plotter	Room
A4	8½" x 11", letter (A size)	Any room printer, HP 8100N	All rooms, T915
A3	11" x 17" (B size)	HP 8100 N	T915
A2	17" x 22" (C size)	HP 1055CM, HP 4500	T915
A1	22" x 34" (D size)	HP 1055CM, HP 4500	T915

B. Drawings larger than 8.5" x 11" (A-size) must be folded to a final size of 8.5" x 11". In all cases, the title block with student name must be visible. Folding instructions are shown in the figures on the following page.

AUXILIARY
NO. BLOCK

TITLE
BLOCK

B SIZE DRAWING COPY

C SIZE DRAWING COPY

D SIZE DRAWING COPY

E SIZE DRAWING COPY

F SIZE DRAWING COPY