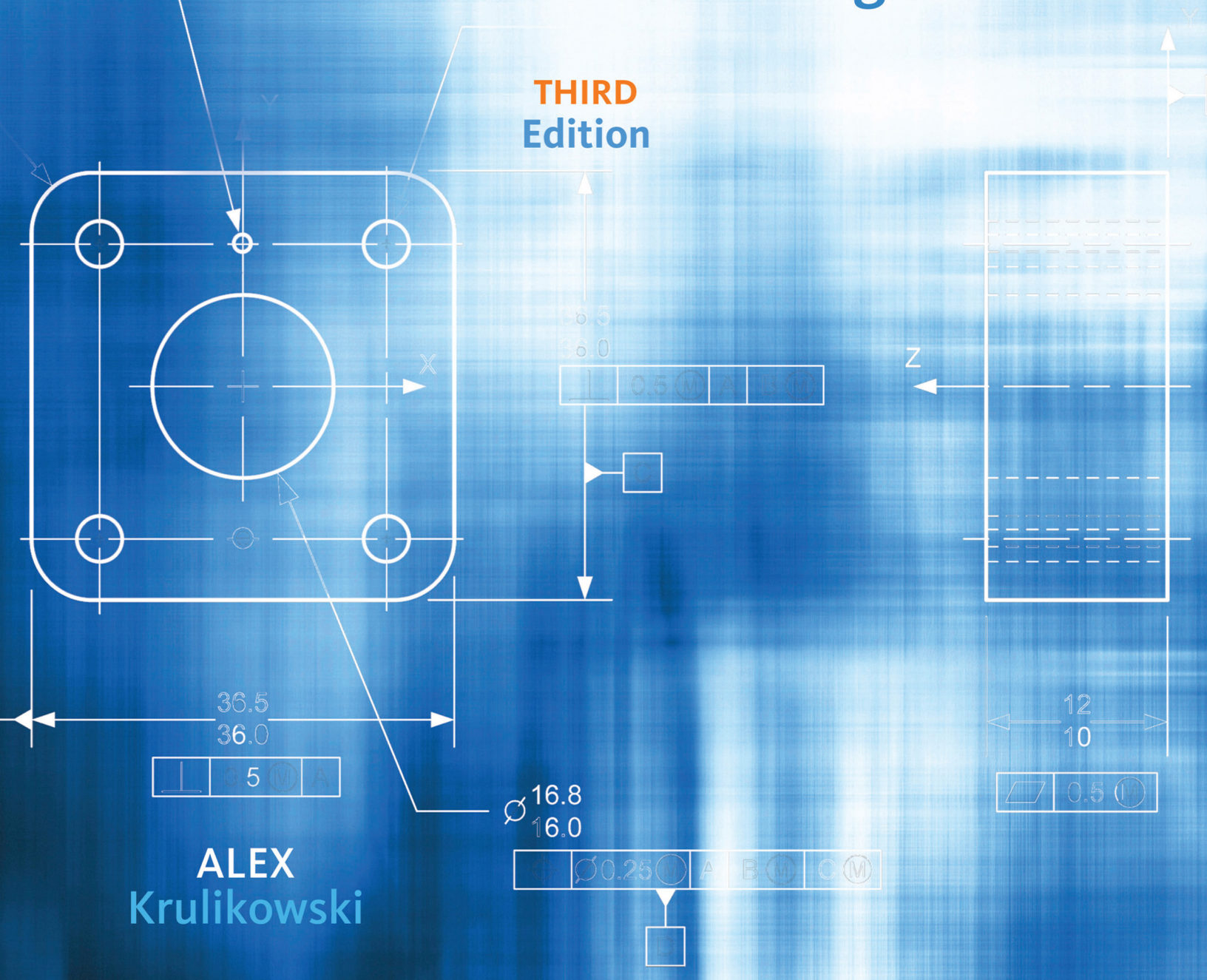
FUNDAMENTALS
of Geometric Dimensioning and Tolerancing

THIRD
Edition



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Fundamentals of Geometric Dimensioning and Tolerancing, 3E

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Drawing Standards

Goal

Understand the importance of standards on engineering drawings

Performance Objectives

Upon completing this chapter, you should be able to:

1. Describe what an engineering drawing is (p.2)
2. Explain the importance of an engineering drawing (p.3)
3. List four consequences of engineering drawing errors (p.4)
4. List the two primary dimensioning and tolerancing standards used globally (p.4)
5. Describe which ASME standards cover dimensioning and tolerancing (p.4)
6. Describe the role of dimensioning and tolerancing standards on engineering drawings (p.5)
7. Identify which dimensioning and tolerancing standards apply to an engineering drawing (p.5)

New Terms

- ASME Y14.5-2009
- Engineering drawing

What This Chapter Is About

This chapter introduces the topics of engineering drawings, dimensioning and tolerancing, and the importance of standards.

Engineering drawings are the documents most companies use to communicate product requirements. Dimensioning and tolerancing is typically used on engineering drawings to define the size, shape, feature relationships, and allowable variation of a workpiece. Standards are necessary to create common specifications and promote common interpretation practices.

A good engineering drawing should be able to speak for itself, it should be able to go anywhere, and competent people should have the same interpretation of the drawing without question.

TERMS AND CONCEPTS

Engineering Drawings

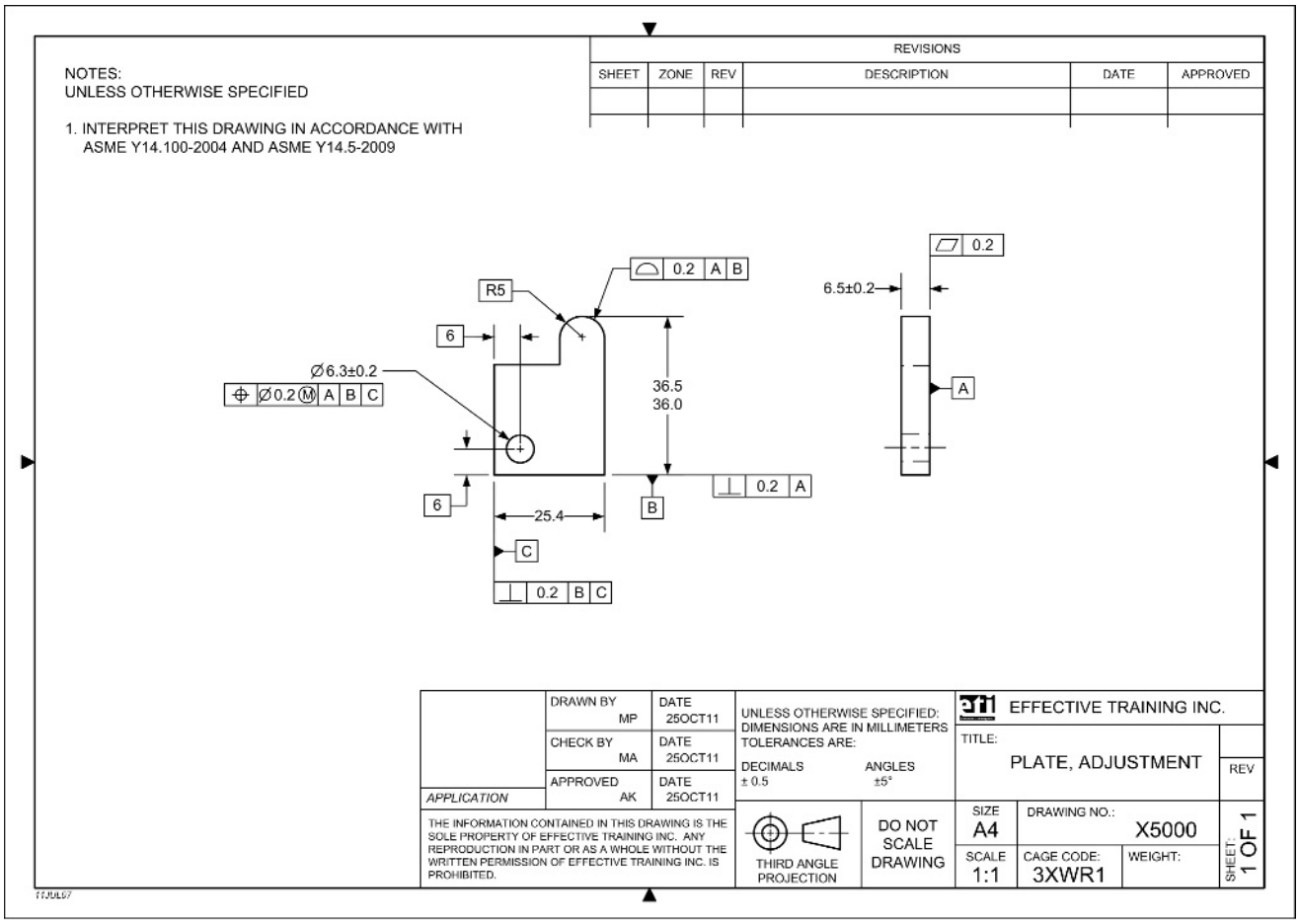


FIGURE 1-1 Engineering Drawing

An ***engineering drawing*** is a document (or digital data file) that communicates a precise description of a part. See Figure 1-1. An engineering drawing consists of pictures, words, numbers, and symbols that are used to communicate the part requirements. An engineering drawing typically includes:

- Geometry (shape, size and form of the part)
- Important functional relationships
- Tolerance (variation) permitted for proper function
- Material, heat treat, surface coatings
- Part documentation information (part number, revision level, etc.)

The engineering drawing is where the engineering requirements of the part are documented.

For more than 150 years, most engineering drawings were created using manual methods on mylar or vellum and were reproduced and distributed as blueprints. However, in the last thirty or so years, engineering drawings have been increasingly created on CAD systems. Figure 1-2 shows a comparison of "then and now" for engineering drawings.

Author's Comment

There are many types of engineering drawings described in ASME Y14.24. This book pertains to detail drawings.

Engineering Drawings		
	Past practices (pre 1980)	Current practices
Drawing medium	Vellum Mylar	Electronic files
Distribution methods	Bluelines Sepia prints White prints	Vendor specific CAD files CAD neutral formats IGES, STEP, JT, PDF files
Drawing creation tools	Compass T-Square Triangles	CAD software programs
Dimension methods	Coordinate tolerancing	Geometric tolerancing of CAD geometry

FIGURE 1-2 Engineering Drawing Practice Comparison

Importance of Engineering Drawings

An engineering drawing is an important document in an organization because it affects the success of both the product and the organization, as shown in Figure 1-3.

The design establishes the goal for a number of departments, so if the drawing is vague, the entire organization is less efficient. Time, money, and resources are wasted until everyone understands what the drawing is intended to convey. In a large organization, as many as 10,000 people may have to interpret an engineering drawing.

The function of a product determines the amount of variation permitted for each dimension. Therefore, the engineering drawing must communicate the allowable variation clearly and in a mathematically repeatable method. Using standards on engineering drawings is an important part of ensuring that drawings communicate clearly.

Author's Comment

Engineering drawings are also used as evidence in product litigation cases.

The manufacturing and inspection costs of a product are affected by the allowable tolerance of each dimension. When manufacturing a part, tolerances affect process selection, tooling, fixturing, etc. Tolerances also affect how a part is inspected, which measurement devices or gages are used, the required accuracy of the gage, and how the part is staged for measurement. To keep costs down, an engineering drawing must communicate clearly and specify the maximum allowable tolerances.

An engineering drawing is a legal document because it combines with the purchase order to form the contractual basis between a customer and supplier. It is also the basis for part acceptance to obtain payment based on the contract.

Because safety, product function, manufacturing, and inspection costs all rely on an engineering drawing, and because it is also a legal document, an engineering drawing is a crucial document in an organization.

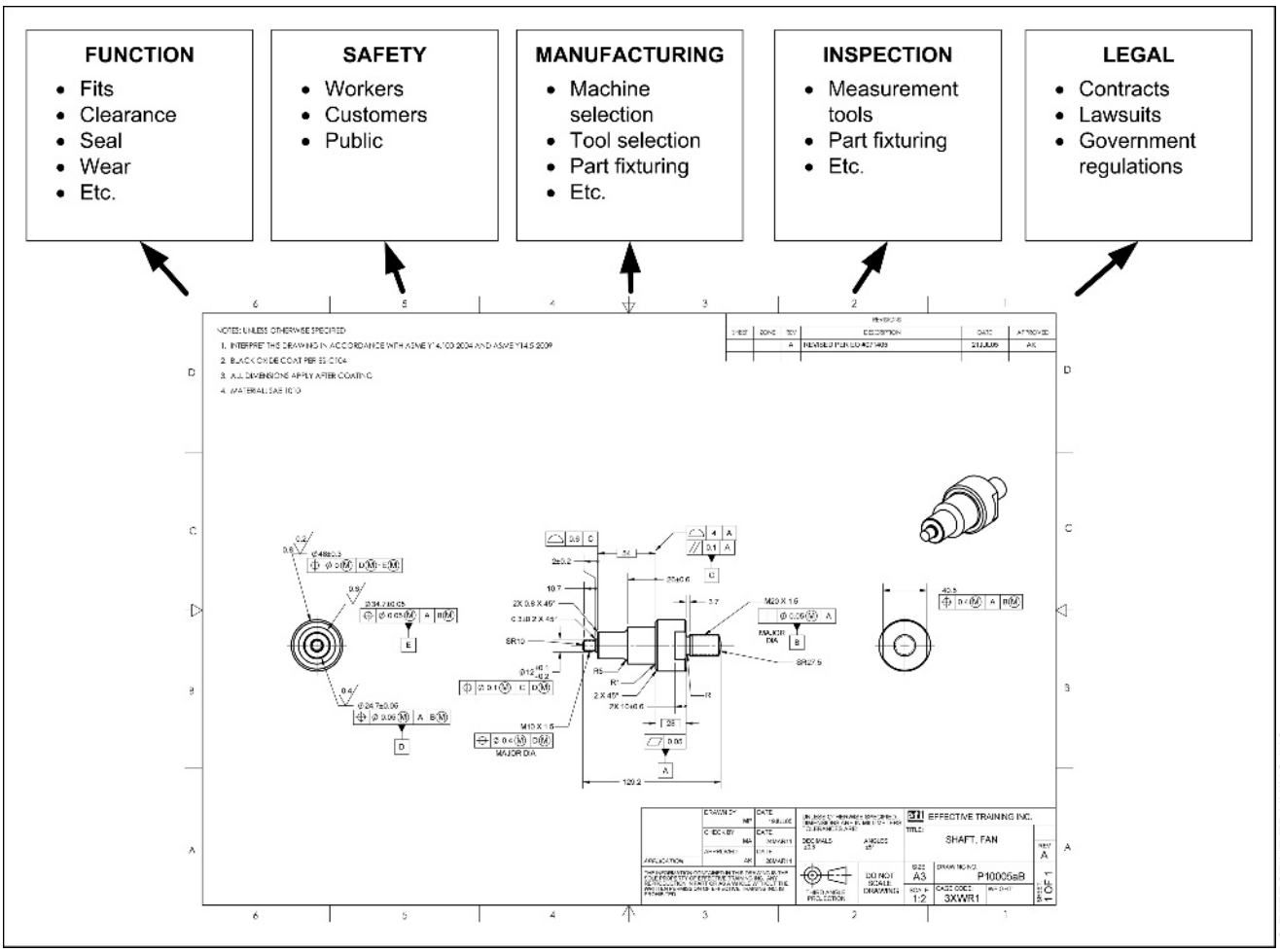


FIGURE 1-3 Impact of an Engineering Drawing in an Organization

The Consequences of Vague or Flawed Engineering Drawings

Engineering drawings not only need to communicate precisely, they also need to be correct. A drawing error can be very costly to an organization. The following analysis is an example based on a medium-sized manufacturing firm.

Figure 1-4 shows typical costs that may result from a drawing error. If a drawing error is found within the design department, it can be corrected for a few dollars. The cost is simply the time required to fix the error, up to about $300.

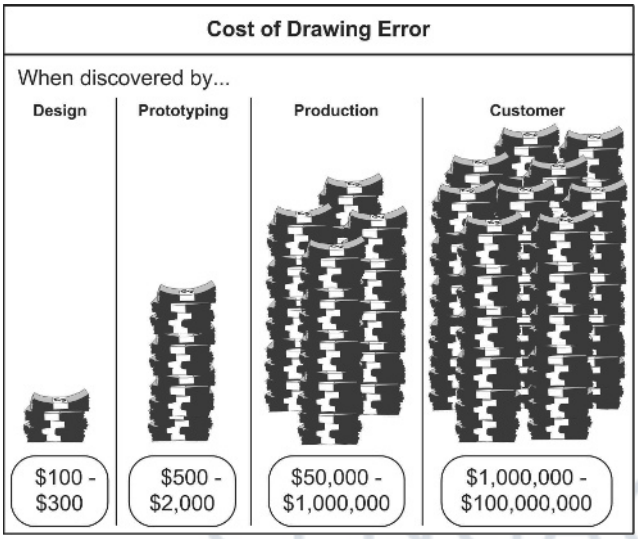


FIGURE 1-4 Costs of a Drawing Error Increase as the Drawing Information is Used to Make Parts

If a drawing error is missed in the design department and is discovered in the model shop, it may cost thousands of dollars to fix the error. This is because now—in addition to the time to fix the drawing—additional costs may be involved in loss of material and machine time, plus tooling and labor costs.

Worse yet, let's say a part described on a drawing that contains an error gets into production. Now the costs escalate quickly. The cost to process the paperwork for fixing the drawing error may be up to sixty thousands dollars. In addition, machine costs, gaging costs, tooling costs, and scrap costs can bring the total to up to a million dollars.

If a drawing error gets into the final product and it's shipped to the customer, the costs that result from the error can be much higher. If a product recall is involved, it can easily cost the organization more than a million dollars. If a product liability lawsuit is involved, the costs that result from the drawing error can run into hundreds of millions of dollars.

Drawing errors cost the organization in four ways:

1. Money
2. Time
3. Material
4. Customer dissatisfaction

DIMENSIONING AND TOLERANCING STANDARDS

Global Standards

There are two major dimensioning and tolerancing standards used around the world. The ASME standards are published by the American Society of Mechanical Engineers and are predominant in the U.S. Although the ASME standards are created in the U.S., they are used on engineering drawings in many countries around the world, so they are considered global standards.

The other major dimensioning and standards are the ISO standards, published by the International Organization of Standards. The ISO standards are developed by international experts and are used globally. This book is based on ASME dimensioning and tolerancing standards. Read about the History of GD&T in Appendix A.

ASME Standards

ASME Y14.5-2009 is the standard for dimensioning and tolerancing. At a minimum, an engineering drawing should specify this standard. An engineering drawing will often invoke several additional standards.

The ASME standards that cover engineering drawings and dimensioning and tolerancing are listed in Figure 1-5. If any of these standards are used, they must be specified on the drawing or invoked by a document referenced on the drawing.

Author's Comment

The ASME and ISO standards look similar, but are very different in application and interpretation. See Appendix E for a comparison of ASME and ISO standards

Corporate standards are another common source of dimensioning and tolerancing standards. A large corporation will often publish an addendum to ASME or ISO standards. The addendum typically covers four items. The addendum may:

- Explain a tolerancing concept in more detail
- Discourage the use of a tolerancing concept
- Select an option from a standard
- Add a tolerancing concept not in the current standards

ASME Drawing-Related Standards*

General Drawing

- Y14.100-2004 – Engineering Drawing Practices
- Y14.1M-2005 – Metric Drawing Sheet Size and Format
- Y14.3-2003 – Multiview and Sectional View Dwgs
- Y14.2-2008 – Line Conventions and Lettering
- Y14.38-2007 – Abbreviations and Acronyms for Use on Drawings and Related Documents
- Y14.35M-1997 – Revision of Engineering Drawings and Associated Documents
- Y14.34-2008 – Associated Lists
- Y14.31-2008 – Undimensioned Drawings
- Y14.24-1999 – Types & Applications of Engineering Dwgs

Dimensioning & Tolerancing

- Y14.5-2009 – Dimensioning & Tolerancing of Engineering Drawings
- Y14.5.1M-1994 – Mathematical Definition of Dimensioning & Tolerancing Principles
- Y14.41-2003 – Digital Production Definition Data Practices (Dimensioning & Tolerancing of Solid Models)
- Y14.36M-1996 – Surface Texture Symbols
- Y14.43-2003 – Dimensioning and Tolerancing Principles for Gages and Fixtures

Part Specific

- Y14.8-2009 – Casting, Forgings, and Molded Parts

* All release dates at the time of publication of this text

FIGURE 1-5 ASME Drawing-Related Standards

The Role of Dimensioning and Tolerancing Standards

Dimensioning and tolerancing standards have a critical role in industry. Standards ensure:

- Common rules and conventions for specifying dimensions and tolerances
- Common interpretations of dimensions and tolerances

Without common specifications of dimensions and tolerances, engineering drawings would be more difficult to understand. Without common interpretation of dimensions and tolerances, it would be impossible to determine if parts meet their specifications. Therefore, dimensioning and tolerancing standards are used on most engineering drawings around the world.

Identifying Which Standards Apply to an Engineering Drawing

Before interpreting an engineering drawing, you must understand which dimensioning and tolerancing standards apply to the drawing. The most common places to find this information are either in the title block or in the notes area of the drawing. Figure 1-6 shows an example of how standards are specified on an engineering drawing.

TECHNOTE 1-1
Standard Identifiers

Many ASME standards can be invoked by referencing an envelope standard, such as ASME Y14.100. However, some standards require that their actual standard identifier be indicated before their rules and practices can be applied. Some examples are Y14.41-2003, Y14.8-2003, and Y14.5-2009.

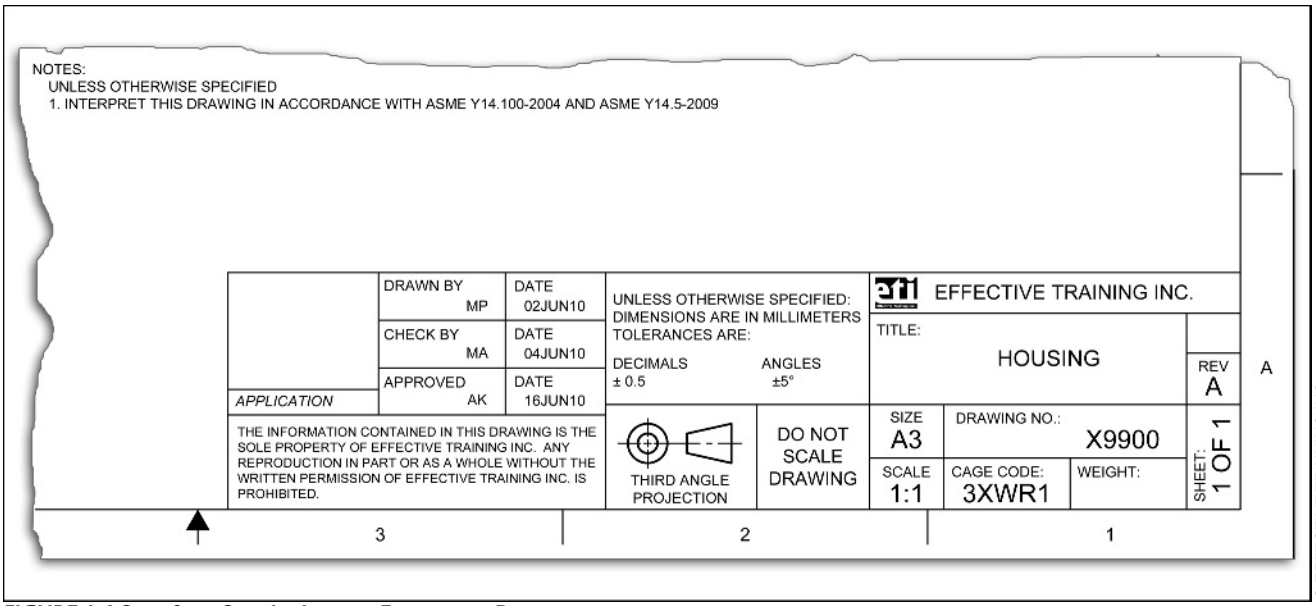


FIGURE 1-6 Specifying Standards on an Engineering Drawing

SUMMARY

Key Points

- An engineering drawing is a document (or digital data file) that communicates a precise description of a part.
- The potential consequences of flawed engineering drawings are wasted time, higher costs, wasted material, and unhappy customers.
- The least costly time to fix a drawing error is while it is still in the design department.
- The two primary dimensioning and tolerancing standards used globally are the ASME and ISO standards.
- The role of dimensioning and tolerancing standards is to establish rules and conventions for common specification and common interpretation of dimensions and tolerances.
- The primary ASME standard for dimensioning and tolerancing is ASME Y14.5-2009.
- The applicable dimensioning and tolerancing standard is typically specified in the title block or in the notes area of an engineering drawing.

Additional Related Topics

These topics are recommended for further study to improve your understanding of engineering drawings.

Topic	Source
ISO/ASME standard comparison	*Alex Krulikowski's ISO Geometrical Tolerancing Reference Guide*
Engineering drawing standards	*ASME Y14.100-2004*
Digital Product Definition Practices	*ASME Y14.41-2003*

QUESTIONS AND PROBLEMS

Website Bonus Materials
Additional questions are available at our website. To access bonus materials for this textbook, please visit:
www.etinews.com/textbookbonus

True and False

Indicate if each statement is true or false.

T / F 1. The function of a product determines the amount of variation permitted for each dimension.

T / F 2. Dimensioning and tolerancing standards are a niche used mostly in high tech industries.

T / F 3. ASME is the only dimensioning and tolerancing standard used internationally.

T / F 4. An engineering drawing is a legal document.

T / F 5. Engineering drawings may affect product safety, tooling, and regulatory compliance.

T / F 6. At the minimum, drawings should reference ASME Y14.5-2009.

T / F 7. The applicable ASME standards may be specified in the general notes.

Multiple Choice

Circle the best answer to each statement.

1. Does the ASME Y14.5-2009 standard apply if it is not indicated on the drawing?
   A. Yes, whenever ASME Y14.100-2004 is indicated, the Y14.5-2009 standard applies.
   B. Yes, all ASME standards apply to all drawings made in North America.
   C. No, Y14.5-2009 requires that it be indicated on the drawing in order for it to apply.
   D. No, all applicable ASME standards must be listed on the drawing.

2. An engineering drawing...
   A. Is a legal document that communicates a precise description of a part
   B. Includes geometry, notes, dimensions, tolerances, and material information for manufacturing purposes
   C. Defines engineering requirements for fit and function of the part
   D. All of the above

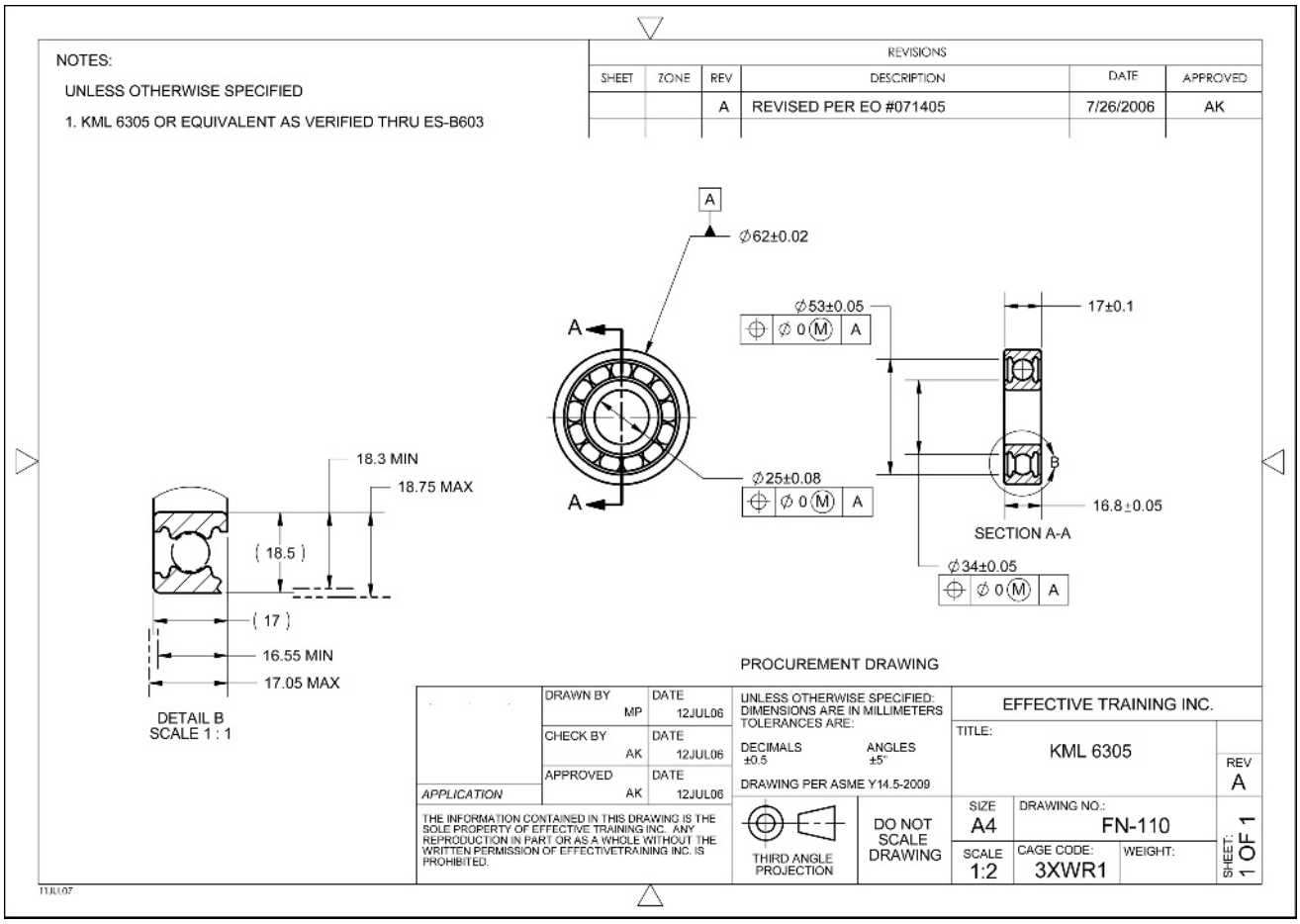
3. Engineering drawings are important because...
   A. The product specifications may affect safety and legal issues
   B. The specified tolerances affect manufacturing, inspection, and tooling costs
   C. The drawing is a legal document that is the basis for part acceptance per the purchase agreement
   D. All of the above

4. If ASME Y14.5-2009 is not specified on the drawing, what may result?
   A. The drawing interpretation may be challenged in court
   B. Ambiguous specifications may lead to nonfunctional parts being accepted and/or higher scrap costs.
   C. An incorrect specification may lead to product failure resulting in customer injury or death
   D. All of the above

5. Where does a drawing user look to identify which dimensioning and tolerancing standards apply to the drawing?
   A. A note in the drawing notes area
   B. A note in or near the title block
   C. In a specification referenced on the drawing
   D. All of the above

Application Problems

The application problems are designed to provide practice on applying the chapter concepts to situations that are similar to on-the-job conditions.



Application questions 1–4 refer to the drawing above.

1. Which dimensioning and tolerancing standard applies to this drawing? _____

2. Should this drawing be considered a legal document? _____Why? _____

   _____

3. What may result if a specification on this drawing is not understood by the manufacturer / supplier? _____

   _____

4. How does ASME Y14.5-2009 affect a manufacturer or supplier (i.e., the recipient of the drawing)? _____

   _____