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Blueprint Reading

OBJECTIVE

The learner will be able to:
» Explain the importance of the skill of blueprint reading for a production technician
» Identify and differentiate between the various types of lines and symbols used in blueprints
» Infer from a blueprint the overall characteristics of a part through geometric tolerances
» Compare and contrast the three views of a blue print
» Formulate a mental model of a part from the three views
» Use the title block to report information about a blueprint
» Utilize a blue print to assess the quality of a product

ORIENTING QUESTIONS

✓ How does a two dimensional drawing helps an engineer to visualize a three dimensional actual object?
✓ How does a blueprint developed by one person interpreted by another person?

INTRODUCTION

Communication is a key tool for the development of any industry. The management communicates the policy and procedures to its employees, customers communicate their requirements, and designers communicate to the manufacturing department. The technical language of communication between the designers and the manufacturers of the product is the blueprint. Blueprints are the instructions for the product manufacturing and it contains all information that is required to produce the final product.

A blueprint is a technical drawing that uses a universal language to communicate information about the product to the craftsman, engineer, designer, and other members of the manufacturing team. The objective of this module is to introduce the basics and importance of blueprint reading, explain and decode the symbols and terms, and explain how to read blueprints. Information and specification of a part of the product is communicated by blueprints in such a way that those parts can be mass produced anywhere in the world.
21.1 Blueprint Reading Basics

The term blueprint originated when the prints had the blue background with white lines. Now those prints are in white background with black lines, however, they are still called as blueprints. Some other common terms used by industry to refer to blueprints include technical drawing, engineering drawing, print, drawings and manufacturing drawings. **Blueprint reading** refers to the act of interpreting the engineering drawing, which helps the designers and craftsmen to get an idea on how the object will look like when it is completed. An example blueprint for the manufacturing a nut along with its blueprint is as shown in the picture. Industries across the globe prepare the blueprints by following the universally adopted standards, symbols and principles of engineering drawings and hence they are correctly interpreted throughout the world. Figure 1 on the right shows an example of a blueprint for a bolt.

21.1.1 BLUEPRINT SHEETS

The blueprints are made on drawing sheets and the size of these sheets are established by consulting various organizations like American National Standards Institute (ANSI), International Organization for Standardization (ISO), American Society for Mechanical Engineers (ASME) and America Institute for Architects (AIA). The standard sizes for blueprint sheets as suggested by ASME Y14.1 are shown in Table 1 to the right.

21.1.2 ELEMENTS OF DRAWINGS

All technical drawing will have some or all of the features that make the drawing interpretable by industry. These elements are discussed below.

» Lines provide the graphic information about the external shape and details of an object. They are of varying shapes and thickness. Object lines are solid lines that form the shape and size of a part. Hidden lines are dotted lines that are not visible in a particular view. Centerlines identify the center of the part that is symmetrical. The size of the part is labeled along with the dimension lines. A break line is a line that denotes that the information is the same throughout but is shown as shortened with a break. A cutting plane line indicates that the view of the diagram is the cross section of the part in certain angle. Figure 2 shows the various types of lines and their representations.
Views provide internal and external features of a part. Normally, basic views are projected from top and side to get a two-dimensional image. The figure 1 has 3 views. We will discuss views in more detail in a later section of this module.

Dimensions provide details of size, position and shape of features. They can also detail information on how to assemble parts. Baseline dimensions are those that provide basic measurements of a part. These dimensions can include length, depth, width, breadth, thickness and angle orientation. Figure 3 shows an example of a basic dimension.

Processes provide information on how each part is produced and is represented by symbols and notes.

Sections are those views of an object that help us to understand the detail of internal construction of an object. Normally the sectional view is obtained by cutting the part using an imaginary cutting plane.

Geometric positions provides a relative position of each part with respect to one another.

21.1.3 IMPORTANCE OF BLUEPRINT DRAWINGS

Blueprints are used in all industries worldwide and are an important way to communicate among personnel of various departments that deal with the technical work. Since the designers or architects who conceptualize the idea may not be able to communicate to the builder and manufacturers, it is necessary to have all the information about the product or facility on the blueprint. Blueprints share the ideas of different levels of an organization and also with the customers who like to share their opinion.

For example, an architect who designs a house for a customer shares the blueprint of the layout. The customer who may not have any knowledge on how to read a technical drawing should be able to understand the basic concepts of the diagram and will be able to share his ideas. Since the blueprint incorporates a vast amount of knowledge, it has become necessary to include of abbreviations, conventions and symbols. Even though the customers may not understand these symbols and notes, the architect or the engineer will be able explain them.

Activity 21.1.3a

Name the organizations that develop standards for the blueprint reading.
Activity 21.1.3b

Identify the type of line shown below.

21.2.0 Symbols Used in Blueprints

As mentioned in the previous section, a blueprint accommodates a large amount of data in a drawing sheet and needs to use a lot of symbols and notations. In this section, we will discuss the various conventions and symbols that are used in a blueprint drawing and where they will be located. The need for these symbols, apart from the basic lines, helps us to reduce the difficulty of drawing the microscopic details of each and every feature.

21.2.1 Thread Representation

One of the major items that we could see on a blueprint is the screw thread. There are three ways to represent a thread on a blueprint. They are detailed representation, schematic representation and simplified representation. A **detailed representation** consists of the real view of the screw thread with details of shape, size, and distance between each groove and so on. The problem with the detailed representation is the amount of time it takes to complete the drawings and the difficulty in drawing such details. A **schematic representation** simplifies the thread details and is shown as parallel lines. The **simplified representation** portrays the information of the design without losing its clarity and requirements. Figure 4 shows the three types of thread representations.
21.2.2 Finishing Symbols

The finish symbols are used in technical drawings to represent the type of texture and smoothness that is required by the product. If the materials are required to be removed from the product, it has to be done by milling, filing, turning, grinding and other metal smoothing methods. A surface finish symbol is used to indicate the type of surface finish required along with the degree of smoothness that it has to achieve.

The basic symbols for finishing are as shown below. The number 32 in each symbol indicates the amount of roughness that is required for the surface. The type of metal removing process that should be implemented for the production process may be mentioned on top of the horizontal bar of the symbol.

21.2.3 Machine Slots

Machine slots are designed to secure two parts together. There are two types of slots: the dovetail and the tee slots. The dovetail is shaped like a trapezoid and the two parts fit together tightly, as shown in the picture.

The T-slot is in the shape of ‘T’ and slides into place to secure two parts together. The T-slots are also similar to the dovetail but are stronger.

21.2.4 Abbreviations

A blueprint also contains abbreviations and symbols in order to convey certain instructions to the craftsmen or production technician. These abbreviations and symbols are universally accepted. Production technicians should be able to identify and differentiate these symbols and abbreviations. Some of the commonly used abbreviations are provided in Table 2.
21.2.5 GEOMETRIC, DIMENSIONING, & TOLERANCES (GD&T)

Geometric, dimensioning and tolerances (GD&T) is the international technical language used in these drawings to describe the size, form, orientation, and location of features of the part. This section will cover geometric tolerances and other symbols, the feature control frame, and material condition modifiers.

21.2.5.1 Geometric Tolerances

Geometric tolerances describe the geometric features of a part, such as straightness, flatness, angularity and roundness.

There are five types of geometric tolerances that describe various characteristics. They are form, profile, orientation, location, and runout. Form tolerances, as the name suggest, describes the form of a part or feature. Profile tolerances describe the boundaries of a surface. Profile tolerances can be very complex as they can define a feature's size orientation, and occasionally, its location. Orientation tolerances describe the direction or orientation of a part or feature. Location tolerances describe the location and placement of a feature or part. And finally, the runout tolerances can describe straightness, profile, angularity and other geometric characteristic variations of a feature or part. Table 3 shows the geometric tolerances discussed and their geometric characteristic symbols.

<table>
<thead>
<tr>
<th>Uses a Datum Reference</th>
<th>Type of Tolerance</th>
<th>Characteristics</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>Form</td>
<td>Straightness</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flatness</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Circularity (roundness)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cylindricity</td>
<td></td>
</tr>
<tr>
<td>Sometimes</td>
<td>Profile</td>
<td>Profile of a line</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Profile of a surface</td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>Orientation</td>
<td>Angularity</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Perpendicularity</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parallelism</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Location</td>
<td>Position*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concentricity</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Symmetry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Runout</td>
<td>Circular runout</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total runout</td>
<td></td>
</tr>
</tbody>
</table>
Table 4 shows the most common of symbols used that can be used.

<table>
<thead>
<tr>
<th>Term</th>
<th>Symbol</th>
<th>Term</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feature control frame</td>
<td>+ 0.003 A B C</td>
<td>Target Point</td>
<td></td>
</tr>
<tr>
<td>Diameter</td>
<td>⊙</td>
<td>Dimension Origin</td>
<td></td>
</tr>
<tr>
<td>Spherical Diameter</td>
<td>S ⊙</td>
<td>Reference Dimension</td>
<td>(50)</td>
</tr>
<tr>
<td>Maximum Material Condition (MMC)</td>
<td>⊙</td>
<td>Number of places</td>
<td>8X</td>
</tr>
<tr>
<td>Least Material Condition (LMC)</td>
<td>⊙</td>
<td>Counterbore/Spotface</td>
<td></td>
</tr>
<tr>
<td>Projected Tolerance Zone</td>
<td>⊙</td>
<td>Countersink</td>
<td></td>
</tr>
<tr>
<td>Free State</td>
<td>⊙</td>
<td>Depth/Deep</td>
<td></td>
</tr>
<tr>
<td>Tangent Plane</td>
<td>⊙</td>
<td>Square</td>
<td></td>
</tr>
<tr>
<td>Statistical Tolerance</td>
<td>(ST)</td>
<td>All Around</td>
<td></td>
</tr>
<tr>
<td>Radius</td>
<td>R</td>
<td>Dimension not to scale</td>
<td>100</td>
</tr>
<tr>
<td>Controlled Radius</td>
<td>CR</td>
<td>Arc Length</td>
<td></td>
</tr>
<tr>
<td>Spherical Radius</td>
<td>SR</td>
<td>Between</td>
<td></td>
</tr>
<tr>
<td>Basic Dimension</td>
<td>50</td>
<td>Slope</td>
<td></td>
</tr>
<tr>
<td>Datum Feature</td>
<td>50</td>
<td>Conical Taper</td>
<td></td>
</tr>
</tbody>
</table>

21.2.5.2 Feature Control Frame

The feature control frame describes the feature that is marked and its geometric characteristic symbol, tolerance value, modifiers, and datum references. Figure 7 shows an example of a feature control frame. The first box holds the geometric characteristics symbol. The second one holds the geometric tolerance symbols along with its modifying symbols and value of the tolerances. The third one refers to the datum reference of the plane. If there are more than one datum as reference the number of compartments are increased to accommodate these datum lines.

The above control frame indicates that the tolerance factor is the position with a cylindrical tolerance of 0.003 of maximum material condition between the datums marked B and C in the blueprint.
21.2.5.3.3 Material Condition Modifiers

Material condition modifiers are found in feature control boxes and are used to refer to a feature in its largest or smallest condition. The maximum material condition (MMC) is the condition of a feature size that contains the maximum amount of material based on the tolerance limits of size. For example, for a hole in a block with tolerances 1.000 in. ± 0.003 the maximum material condition is the smallest size limit, which in this case is 0.997 in. Differing from MMC, the least material condition (LMC) is the condition of a feature size that contains the least amount of material based on the tolerance limits. For example, for a hole in a block with tolerances 1.000 in. ± 0.003 the maximum material condition is the smallest size limit, which in this case is 1.003 in. If we had an external feature, then the least material condition of that external feature would be the smallest size limit.

Activity 21.2.5.3a

» Match the symbols with the term.

Activity 21.2.5.3b

» Identify types of lines and symbols used in the below diagram.
21.3.0 Three View Drawings

In creating a blueprint, it is assumed that the lines of observation by an observer travel only in parallel to the direction of observation and perpendicular to the object being observed. When an object being observed is a simple part like a sheet or a rod, then we need only one view to incorporate the details on a print. But when the part is complex we may need at least 3 views to interpret and describe the various details of the part on the print.

21.3.1 THREE VIEW DRAWINGS

In most of the objects or parts, a combination of the side view, top view and end view is sufficient to interpret the specifications of the parts by the draftspersons. The various steps that are followed in obtaining each of these views are explained in this section. Through an example, Figure 8, the three views will be explained.

The side view is the representation of the part in which an observer sees the part at the first time. For the above image suppose that you are looking at the cylinder from the arrow marked as side view. The resultant image that we get when we draw that from the side view is as shown below. The small hole is shown in this diagram since it is visible from the front view. Similarly the top view is also drawn. This time the observer sees the object from the top side and is marked in the picture above. Here we could see that the part where the hole was present is shown has hidden lines since this will not be visible from the top angle. To obtain the end view, the direction of looking is changed to the side of the cylinder and a circular image is obtained. We could see the hollow part of the cylinder in this view and also shows the two rings on for the inner tapered circle and the other for the outer cylinder diameter. The combined diagram that has the top view, side view and the end view. A three view drawing, or combination drawing, is a drawing has all three views.
Activity 21.3.1

Using the figure below, identify the following:

- Diameter of the hole in the cylindrical face
- Distance of the hole from the circular base
- Total length of the cylinder
- Diameters of inner and outer cylinder from the circular base side

A title block, which is normally placed at the bottom right corner of the drawing sheet, provides the details to improve the understanding of technical drawings. The various items that are present in the title block are defined in this section. Figure 9 provides an example of a title block.
» **Owner name**: Includes the name of the owner of the document. It could be the company, enterprise or the person who owns the drawings.

» **Identification Number**: It is a unique number for that particular company to identify the drawing and to incorporate a standard naming convention for the document to retrieve it from the storage.

» **Sheet number**: Provides an easier way to number the sheets if there are multiple sheets required for a drawing.

» **Date of issue**: Provides the final date when the document was formally released for use by various departments.

» **Revision number**: If there was a suggested change to the initial drawing a revision number is provided and is incremented every time the drawing is issued officially. This field could contain a combination of alphabets and numbers that could be used as a standard for a particular organization.

» **Document Status**: Provides information if the drawing is pending approval, released, or withdrawn from production.

» **Title**: Title contains the content of the drawing and more details could be provided below the title as a supplementary title that provides more information.

» **Document type**: The purpose of the document type is to provide the type of the drawing if it is a schematic representation, or pictorial representation.

» **Responsible department**: Denotes the name of the department who is responsible for the content creation, revision and maintenance of the drawing. Any changes to be made to the drawing should go through the department mention in this section.

» **Technical reference**: Incorporates the name of the person who has sufficient knowledge about the diagram and all queries could be answered by this person or department.

» **Creator**: Creator is the person who made the drawing and changed the drawing.

» **Approval Person**: The name of the specialist who reviewed the drawings is included in this section. If there is more than one person who reviewed and approved the document, then all their names should be listed here.

### 21.4.1 CHANGE BLOCK

The change block is defined as that area in the blueprint that includes all changes and revisions made to the initial print. The change block will be present in those blueprints whose revision number is greater than zero. The change block is relevant in all blueprints to accurately track all the changes made on the blueprint along with the person who made the change. When a specification of a particular part is changed, and if the change is minor, instead of making the exact change in the line, it could be indicated in the change notes. For example if the line 01 is increased by 0.005 inches we note that at the change block in **Figure 10**.
Activity 21.4.1

Using the title block below, identify each box.

Figure 10. Example of a change block

![Example of a change block](image)

21.5.0 Surface Texture for Materials

Even though the material used to make the product is mentioned in the title block, certain shadings are provided on the drawings to represent some of the common surface texture used in manufacturing. Some of the common surface texture characteristics for a material include lay, flaw, waviness, roughness height and roughness width. The variations on the surface from its nominal surface indicates the surface texture and is denoted by various patterns based on the materials. A few patterns are as shown Figure 11.

Figure 11. Sample of material patterns

![Sample of material patterns](image)

- Rubber
- Cast Iron
- Zinc
- Electrical Windings
- Aluminum and its alloys
- Transparent materials
When a part undergoes machining process, it produces a pattern of lines on top of the surfaces and is known as lay. The direction of lines in the pattern could be perpendicular (^), parallel (//), angular (X), multidimensional (M), circular (C) or radial (R). These are indicated by their symbols in the blueprints. The series of waves that are produced on the surface of the material is indicated as waviness depth and waviness height on the blueprint. The defects on the surface texture are indicated as which include scratches, burrs, and other imperfections on the surface. A sample representation of all surface texture properties is shown in the picture below.

21.6.0 Blueprints in the Production Floor

In this section a few examples of the blueprints will be introduced and explained using the various terms presented in this module.

21.6.1 SPOOL

A spool is a cylindrical reel in which a thread, wire, cable or film are wound on it. A spool has a cylindrical rod at the middle that connects to a circular disc shaped plates on either ends. The blueprint below shows the view of a spool and since only 1 view is required to obtain the required details about this part, the view is called a single view drawing.

Now we will discuss the various features that are present in this blueprint (refer to Figure 13).

» The blueprint is drawn to a scale of 1:1 (marked as A) which implies that the image has dimension of the actual item. If the scale is 1:2 then it implies that 1 inch in the drawing corresponds to a 2 inch in the actual item

» The title block (marked as B) contains the details about the owner of the drawing, size, the person who created this, title of the drawing, date it was issued and the sheet number

» The dimensions are as discussed below:
  - Total length is 3.00 Inches (marked as C)
  - Thickness of the disc is 0.25 inches (marked as D) and that of the cylindrical rod is 0.75 inches (marked as E)
  - The inner radius of the hollow cylinder that connects the two discs has a radius of 0.25 inches (marked as F) and the inner edges needs to be reamed
  - The outer edge needs to be chamfered that has a distance of 0.0625 inches (marked as G).
  - The joint between the disc and the cylindrical rod has a curve and the radius of that curve is 0.125 inches (marked as H).
  - The total diameter of the disc is 2.38 inches (marked as I).
A ball valve stem is a part of the ball valve system that controls the flow of liquid through it in either direction. The stem controls the movement of balls inside the valve that aids the liquid flow. The blueprint of the stem requires a three view drawing to capture whole specifications.

Now we will discuss the various features that are present in this blueprint (refer to Figure 14).

- The blueprint is drawn to a scale of 4:1 (marked as A) which implies that a 4 inch in the drawing corresponds to 1 inch in the actual part dimension.
- The title block (marked as B) contains the details about the owner of the drawing, size, the person who created this, title of the drawing, date it was issued and the sheet number.
- There are 3 views in the drawing and they are the top view (C), side view (D) and end view (E).
- Top view dimensions are discussed below:
  - Diameter of the threaded part is 0.1865 inches (F).
  - Thickness of the stem holder is 0.22 inches (G).
  - The rounded edges for the top part of the stem that is in a disc shape has a radius of 0.0078 inches (H) and the junction between the disc and the threaded part has a rounded edge with a radius of 0.03125 (I) inches.
– The part that connects to the threaded part and the top part has a total distance of 0.01750 inches and is chamfered at an angle of 45 degree (J).

» Side view dimensions are discussed below
– Total length of the item is 1.224 inches (K)
– Length of the threaded part is 0.6805 inches (L)
– The distance between the threaded part and the disc is 0.32 inches (M)
– Thickness of the disc is 0.0535 inches (N)
– Distance between the disc and the holder is 0.17 inches (P)
– The tip of the threaded part is chamfered at an angle of 45 degree and has a length of 0.03125 inches (Q)
– Diameter of the part that holds the threaded part is 0.3475 inches (R)
– The radius of the holder is 0.25 inches (S) and there is a rounded edge between the holder and disc with a radius of 0.01583 inches (T)

» End view dimensions are discussed below
– The diameter of the disc is 0.467 inches (U)
– The radius of the edges of the holder is 0.19725 inches (V)

Figure 14. Example of a blueprint: Ball valve stem
SUMMARY

Key Concepts

» A blueprint is a technical drawing that uses a universal language to communicate information about a product.

» Being able to read blueprints is an important skill for a production technician. This skill assists in communication between technicians and designers.

» Blueprints can contain various types of lines and symbols. Being able to identify and differentiate between these will provide an effective interpretation of blueprints.

» Blueprints help determine the required geometric characteristics a product must have to meet quality.

» The three views are able to show the technician up to two dimensions and geometric tolerances. Using these three views, a technician can develop a mental model of what the part should be.

» A title block provides the details of a drawing such as, the owner’s name, the identification number, the date of issue, the revision number, and the person who can approve changes to the blue print.

» Shadings are provided on blueprint drawings to represent some of the common surface textures used in manufacturing.

Key Terms

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21.2 Detailed representation pg.4
Schematic representation pg.4
Simplified representation pg.4
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T-Slot pg.5
Geometric, dimensioning, and tolerances (GD&T) pg.6
Form tolerances pg.6
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Further Study

For more information on the production methods used for certain products, use the internet or your local library to find books and articles about the particular manufacturing industry.

» **Baseline dimensions:** Dimensions provide basic measurements of a part; these dimensions can include length, depth, width, breadth, thickness and angle orientation

» **Blueprint reading:** Act of interpreting the engineering drawing, which helps the designers and craftsmen to get an idea on how the object will look like when it is completed

» **Blueprint:** A technical drawing that uses a universal language to communicate information about the product to the craftsman, engineer, designer, and other members of the manufacturing team

» **Change block:** The area in the blueprint that includes all changes and revisions made to the initial print

» **Detailed representation:** A type of thread view that consists of the real view of the screw thread with details of shape, size, and distance between each groove and so on

» **Dovetail:** A slot that is shaped like a trapezoid and is used to secure two parts together

» **End view:** The representation of the part which shows the true height and width, but not the depth

» **Feature control frame:** Describes the feature that is marked and its geometric characteristic symbol, tolerance value, modifiers, and datum references

» **Flaws:** Indicates defects like scratches, burrs and other imperfections on the surface of a part after a machining process

» **Form:** Geometric tolerances that describes the form of a part or feature

» **Geometric, dimensioning and tolerances (GD&T):** International technical language used in these drawings to describe the size, form, orientation, and location of features of the part

» **Lay:** The pattern of lines on top of the surface of a part after a machining process

» **Least material condition (LMC):** The condition of a feature size that contains the least amount of material based on the tolerance limits; for example, the least material condition of an internal feature, like the hole in the block, is the largest size limit; for an external feature, then the least material condition of that external feature would be the smallest size limit

» **Location:** Geometric tolerances that describes the location and placement of a feature or part

» **Material condition modifiers:** Are found in feature control boxes and are used to further define the tolerance of a feature as it relates to its acceptable size limits

» **Maximum material condition (MMC):** The condition of a feature size that contains the most amount of material based on the tolerance limits of size; for example, the maximum material condition of an internal feature, like the hole in the block, is the smallest size limit; for an external feature, then the maximum material condition of that external feature would be the largest size limit

» **Orientation:** Geometric tolerances that describes the direction or orientation of a part or feature

» **Profile:** Geometric tolerances that describes the boundaries of a surface

» **Runout:** Geometric tolerances that can describe straightness, profile, angularity and other geometric characteristic variations of a feature or part
» **Schematic representation:** A type of thread view that simplifies the thread details and is shown as parallel lines

» **Side view:** The representation of the part which shows the true height and depth, but not the width

» **Simplified representation:** A type of thread view that portrays the information of the design without losing its clarity and requirements

» **Surface finish symbol:** Used to indicate the type of surface finish required along with the degree of smoothness that it has to achieve

» **Three view drawing:** Is a drawing has had all three part views: side, top and end view. Also known as a combination drawing

» **Title block:** Located at the bottom of a blueprint, it provides the details to improve the understanding of technical drawings

» **Top view:** The representation of the part which shows the true width and depth, but not the height

» **T-slot:** A slot that is shaped like a ‘T’ and is used to secure two parts together

» **Waviness depth:** Indicates the depth of the waves produced on the surface of a part after a machining process

» **Waviness height:** Indicates the height of the waves produced on the surface of a part after a machining process
## Attribution Tables

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<th>Title</th>
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<td>Figure 2 - Various types of line</td>
<td>Drawing and illustrations created by CUCWD staff</td>
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<td>CUCWD - TW</td>
<td>Thread representation</td>
<td>Drawing and illustrations created by CUCWD staff</td>
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<tr>
<td>Tee-Slot</td>
<td>Figure 5 - T-Nut Installed in a T-Slot.png</td>
<td><a href="http://commons.wikimedia.org/wiki/File:T-Nut___Installed_in_a_T-Slot.png">http://commons.wikimedia.org/wiki/File:T-Nut___Installed_in_a_T-Slot.png</a></td>
<td>CC-BY-SA-3.0</td>
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<td>CUCWD - TW</td>
<td>Figure 7 - Cylindrical CAD drawing</td>
<td>Drawing and illustrations created by CUCWD staff</td>
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<td>CUCWD - TW</td>
<td>Figure 8 - Cylindrical CAD drawing</td>
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<td>CUCWD - TW</td>
<td>Figure 9 - Cylindrical CAD drawing</td>
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<td>CUCWD - TW</td>
<td>Figure 10 - Cylindrical CAD drawing</td>
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<td>CUCWD - TW</td>
<td>Figure 11 - Dimensions</td>
<td>Drawing and illustrations created by CUCWD staff</td>
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<td>Construct</td>
<td>Figure 12 - Title block according to EN ISO 7200 in English language</td>
<td><a href="http://en.wikipedia.org/wiki/File:Title_block_EN_ISO_7200.svg">http://en.wikipedia.org/wiki/File:Title_block_EN_ISO_7200.svg</a></td>
<td>CC-BY-SA-3.0</td>
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<td>CUCWD - SCM</td>
<td>Figure 13 - Pattern</td>
<td>Drawing and illustrations created by CUCWD staff</td>
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<td>Dmeranda</td>
<td>Figure 14 - Spool of white thread</td>
<td><a href="http://upload.wikimedia.org/wiki-pedia/commons/0/0a/Spool_of_white_thread.jpg">http://upload.wikimedia.org/wiki-pedia/commons/0/0a/Spool_of_white_thread.jpg</a></td>
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<tr>
<td>David Tuders</td>
<td>Figure 15 - Spool</td>
<td>Used with permission</td>
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<tr>
<td>David Tuders</td>
<td>Figure 16 - Stem</td>
<td>Used with permission</td>
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