

**EVALUATING  
ACADEMIC READINESS  
FOR APPRENTICESHIP TRAINING**  
Revised for  
**ACCESS TO APPRENTICESHIP**

**COMMUNICATIONS SKILLS  
INTERPRETATION OF DIAGRAMS**

**AN ACADEMIC SKILLS MANUAL  
for  
The Precision Machining And Tooling trades**

This trade group includes the following trades:  
General Machinist, Tool & Die Maker,  
Mould Maker, Pattern Maker, and  
Machine-Tool Builder Integrator)

*Workplace Support Services Branch  
Ontario Ministry of Training, Colleges and Universities*

*Revised 2011*

In preparing these Academic Skills Manuals, we have used passages, diagrams and questions similar to those an apprentice might find in a text, guide or trade manual.

**This trade related material is not intended to instruct  
you in your trade. It is used only to  
demonstrate how understanding an academic skill will help  
you find and use the information you need.**

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# COMMUNICATIONS SKILLS: INTERPRETATION OF DIAGRAMS

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*An academic skill required for the study of the  
Precision Machining and Tooling Trades*

## **INTRODUCTION**

You've probably heard this expression: "A picture is worth a thousand words." It means that something you can see would take a thousand words to explain. The purpose of graphic material (diagrams, charts, pictures) is make information about your trade easy to see. The correct *interpretation of diagrams* is necessary in order for you to benefit from the information they contain.

The information in a diagram might illustrate a new concept, show the correct order of the steps of a procedure, or provide the requirements and measurements for a machining job. You need to be capable of interpreting scale drawings to locate dimensions on drawings and plans to complete material layouts and identify angles to verify the placement of and between parts and sub-units such as tools onto progressive dies. Moreover, you need to be able to view three-dimensional representation of parts and machining processes on the display panels of CNC machinery. Clearly, *interpretations of diagrams* skills are essential for your technical reading toolbox.

Accuracy is essential in the precision machining and tooling trades. Diagrams can provide details about areas that you can't see or touch. When you don't have access to hidden structures, you rely on diagrams to provide the background information needed to work precisely and safely.

Other graphics such as charts and tables list details such as measurements in a way that makes it easy to find the correct component needed for a specific situation. Pictures can give you a visual idea of the end result, or they can show differences in related items.

Interpreting graphics correctly is an essential skill to develop as you master the knowledge and techniques of your trade. We will examine:

- ◆ Standard symbols and diagrams
- ◆ Symbols and diagrams as visual language
- ◆ Diagram and text that interpret information
- ◆ Information in text and diagrams that match

## **PART I DIAGRAMS AND STANDARD SYMBOLS**

### **Graphics**

The term *graphics* refers to the various types of technical drawings and charts used in your trade. Graphics are a means of communicating complex ideas in a small space. Graphics serve many

purposes: they illustrate concepts, show relationships and compare information. A chart can organize detailed information in a coherent way so you can easily find what you need. A diagram can show how something works, illustrate a method, and show you the locations of features in a part. This is especially useful in showing where hidden features are situated.

## Symbols

As you learn your trade, you will be introduced to many symbols. Symbols are a shortened form of language. An object, process, relationship or number can be converted into a symbol. Many symbols are international. When you come across a symbol in your reading or on the job, you need to learn what term the symbol stands for and you also need to know what the term means.

**Example:** These three international symbols demonstrate this:

×	multiplication symbol	Multiplication is indicated by the symbol <b>x</b> . The <b>x</b> symbol immediately identifies a process. It also tells you what to do.
CO <sub>2</sub>	carbon dioxide symbol	The relationship between a carbon molecule and an oxygen molecule can be stated symbolically. The symbol <b>CO<sub>2</sub></b> stands for or represents carbon dioxide. The <b>C</b> stands for a carbon molecule; the <b>O</b> stands for an oxygen molecule; the <sub>2</sub> tells you there are two oxygen molecules. Glance back over this explanation on <b>CO<sub>2</sub></b> . "A symbol is worth a thousand words".
M	number symbol for million	Many numerical amounts are represented by symbols. <b>M</b> is the first letter of the Greek word mega (great) and it is used to represent the number million.

While many symbols, such as the ones shown above, are international, some countries and some agencies have their own symbols. The International Standards Organization (ISO), the Canadian Standards Association (CSA) and the American National Standards Institute (ANSI) are different accredited groups that use their own symbols. The following extract from a table of hydraulic and pneumatic symbols tells you that *ISO* has published these symbols.

### Example:

**Table 1: Basic Hydraulic and Pneumatic Symbols**

ISO Symbols	Definitions
▼	Hydraulic Flow
△	Pneumatic flow
➔	Indication of variability

## Symbols in text

Symbols are routinely used in technical writing and in drawings.

**Example:** Most anti-friction bearings require a shaft surface finish of up to 0.30  $\mu$  m **AA** (12  $\mu$  in.). Too rough a surface finish may result in loss of interference fit, excessive shaft wear, and fretting of the bearing seat.

The purpose of the paragraph below is to pass along specific information about an aspect of your trade - *shaft surface finish*. Your ability to follow directions depends on your ability to understand the meaning symbols such as  $\mu$  m, **AA** and  $\mu$  in. If symbols used in the text or diagrams are unclear, you need to look them up.

We have listed the meanings of these symbols below:

$\mu$  m = symbol for micrometers. A micrometer is one millionth of a metre (0.000 001 metres)

$\mu$  in. = symbol for micro inches. A micro-inch is one millionth of an inch (0.000 001 inch)

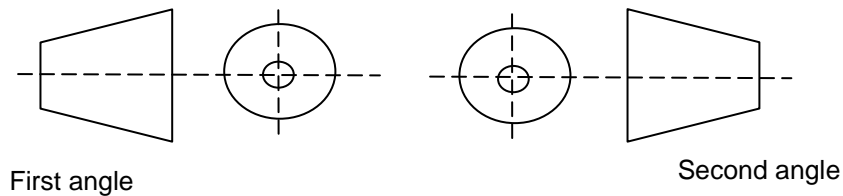
**AA** = refers to arithmetical average height of surface roughness

As you learn your trade, you will encounter many symbols – some will be familiar and others will be new. It is your job to learn what they mean to add to your understanding of the concepts, principles, and “language” of your trade.

### Which way is up?

Symbols help explain information.

**Example:** Objects shown at right angles can be viewed from different positions. The symbols in Figure 1 indicate the angle at which you view an object. They show whether you are viewing from left to right (**first-angle**) or from right to left (**third-angle**).



**FIGURE 1: ISO Symbols For The First- And Third- Angle**

Symbols are shorthand for something. You need to know how to unlock the meaning presented by a symbol in a text or drawing. Each symbol transfers information to you efficiently, but you need to know precisely what it stands for. The difference between  $30^\circ$  and  $30''$  is significant.

### Purpose

*Your purpose in learning symbols is to learn to read and speak the language of your trade. You need to interpret both written material and any graphic material found in the text to understand and use the information presented.*

## **PART II**

### **SYMBOLS AND DIAGRAMS AS VISUAL LANGUAGE**

Once you learn the meanings of trade symbols, you can recognize their meaning when you come across them in later sentences. This is the next sentence in the paragraph about shaft surface finish in the earlier example.

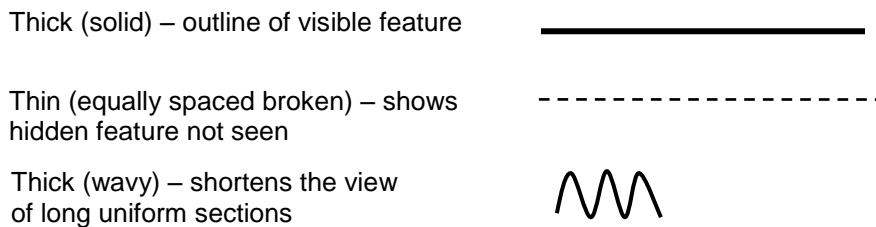
Babbitt and bronze sleeve bearings require a finish of up to  $0.81 \mu$  m AA ( $32 \mu$  in.).

You already know the meaning of  $\mu$  m, **AA** and  $\mu$  in, so you can figure out what the sentence is saying.

### Lines mean something

Lines used in technical drawings convey meaning. Lines can be *thick* or *thin*; broken, with equal spacing; broken with long/short spacing and so on. Lines provide you with information. As with symbols, *standards apply to these lines and define their meaning* in the trades. Different lines mean different things and the information they convey must be exact.

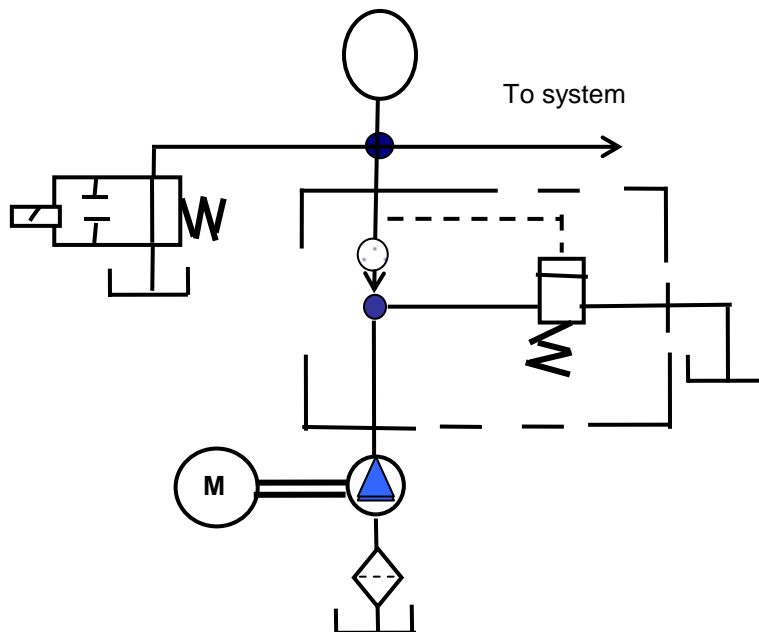
Canadian Standards define line thicknesses as *thick* or *thin*: *thick* is at least twice the thickness of *thin*. It is essential that you recognize what each line stands for in a chart or diagram. Figure 2 contains some samples to illustrate this:



**Figure 2: Examples Of Lines In Technical**

### What does this mean?

A diagram that contains lines and shapes is abstract in that it represents something real but it doesn't look like the real thing. Look at the diagram of an automatic bleed-down circuit



**FIGURE 3: Automatic Bleed-Down Circuit**

As you can see, working diagrams don't always look like what they represent. In Figure 3, the circle with **M** in the middle stands for motor. This certainly doesn't look like a motor but, when you know **M** represents a motor and you see it in a diagram, you know that the diagram includes a motor.

Each symbol you can interpret increases your ability to understand and use information presented in diagrams. Lines in drawings provide exact information about an object or a process. Figure 3 uses lines and symbols to show a series of relationships. It is a stripped down, but concise, visual language. Each part of this diagram conveys information about the placement of the following in an automatic bleed-down circuit:

- flow lines
- springs
- motor

### Road maps

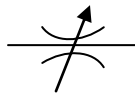
Compare Figure 3 to a road map. A road map gives you an overview of a whole system: compass directions, routes, distances, names of places. From it, you can calculate distance and travelling time, determine stopping points, plan routes. A figure with each of its symbols is like a map to use as a guide to essential trade information.

## PART III

### DIAGRAMS AND TEXT INTERPRET INFORMATION

#### Diagrams

Diagrams relate to something real. They show you how to do something, what something looks like, or the things that you can't see such as the flow of liquids or electrons. In some cases, the diagram looks like the real thing (such as the drawing of a tool); in other cases, it represents but does not look like the real thing such as this drawing of a symbol for a throttle valve



#### Figures

When you are reading, you might be directed to a graphic, which is usually labelled as a Figure with a number. The reference to the graphic may be in parentheses like this (Figure 2-10). Or, the text may tell what the graphic will show you.

**Example:** The vanes of this turbine stator as shown in Figure 12-5 are integrally cast of high alloy cast iron. They are not machined.

#### Read everything

Knowing the purpose of a graphic helps you interpret what is being conveyed to you. It's important to get all the information available from a graphic. The information is there to help you develop a clear understanding of the principles and concepts required by your trade.

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## Labels and headings

Headings, titles and labels add to the information available in diagrams and help you interpret the information. Be sure to read all titles and headings. The labels or descriptions in a diagram identify what you are looking at; they may contain directions or point you to an important aspect of the diagram.

*Use all the information provided by labels and written descriptions within the diagram to get the complete picture.*

To interpret a diagram, start by reading the label. A label offers important information. It may

- ◆ identify the diagram,
- ◆ describe how to follow the information on the diagram,
- ◆ refer you to the text for clarification,
- ◆ highlight important points.

Diagram labels provide a focus for the information presented. Here are some samples of labels attached to diagrams. Each label gives more information than the one before it and each label relates to the graphic *and* text.

**Figure 1** Parts of gear

**Figure 2** Using a gear gauge

**Figure 3** Hydraulic effect and backlash of meshing gears

## Using Text and Diagram Together

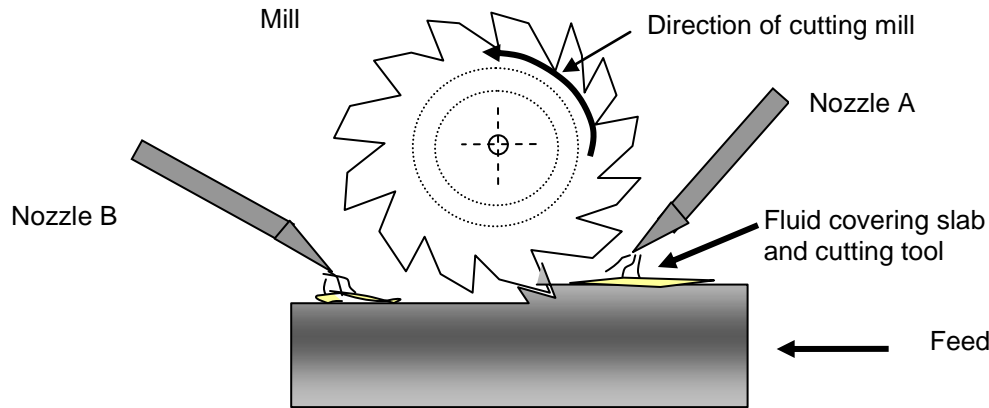
Figure 4 provides key information about applying cutting fluids. The text and diagram are important and useful on their own, but together, they give a more complete picture.

### Passage 1

#### Application of Cutting Fluids

The method of applying cutting fluid has a pronounced effect on both the life of a cutting tool and the machining operation. Cutting fluid needs to be supplied in a generous stream under low pressure so both the work and the cutting tool are covered well. It needs to be directed to where the chip is forming in order to reduce and control the heat created during the cutting action and to prolong tool life.

In *slab milling*, cutting fluid should be directed to both sides of the cutter by fan-shaped nozzles about three-fourths the width of the cutter (Fig. 4)



**FIGURE 4: Cutting Fluid Being Supplied To Both Sides Of The Cutter In Slab Milling**

The diagram has a clear purpose: it gives you a good idea of slab milling. The different parts are labelled. It is simplified: you get enough information to see the process but not so much that it is confusing. It uses symbols to show details: the centre of the mill (circle with crossed lines) and the direction of movement of mill and feed (arrows).

The diagram aids your understanding of one aspect of slab milling. You can "see" cutting fluid supplied:

- in large amounts so that the cutting tool is well covered;
- to the area where the chip is being formed;
- from both sides of cutter; and
- through the fan-shaped nozzles.

The **text** provides further explanations and directions not found in the diagram. The **diagram** shows concepts which are difficult to put into words. The diagram and the text differ; yet, **they work together** to describe an important process, to give reasons for it and to provide a mental and visual understanding of it.

When you have read and understood both the graphic and the text, you should be able to:

1. List two purposes of a cutting fluid.
2. Show where the cutting fluid should be applied.
3. Explain why the cutting tool and work should be covered.

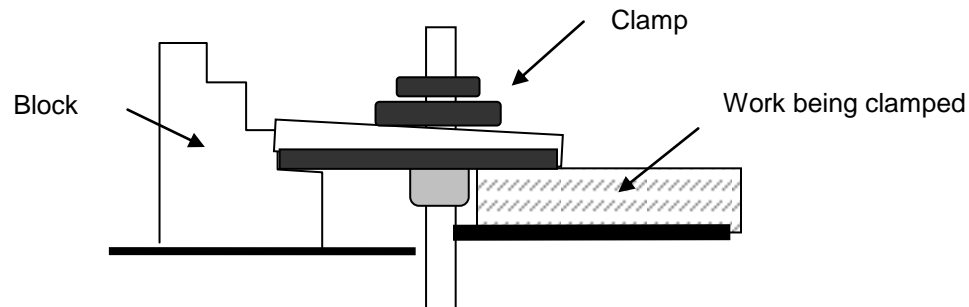
### **How not to . . .**

Technical drawings often show you how to do something. The text describes the actions to be done and explains the reasons for doing them, while the drawings show how to perform those actions. Examining both text and drawings helps you accurately follow directions and avoid problems.

In the next example, the text describes how to clamp to a drill-press table in a correct and then an incorrect way. The diagrams illustrate both ways.

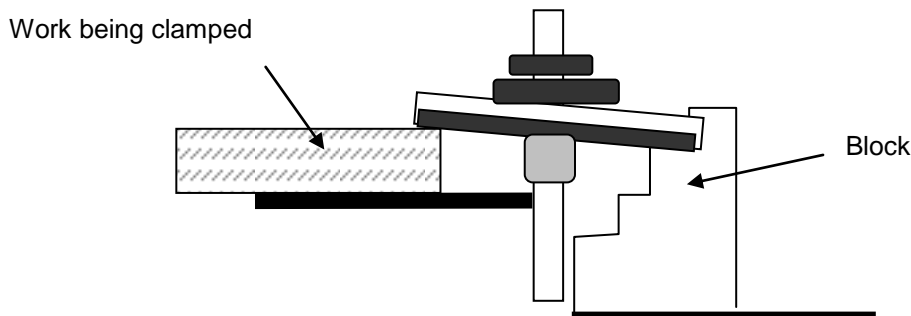
**Passage 2**  
**Drill Press Table**

The work piece must be held securely for any drill-press operation. The clamps, bolts, and packing blocks must be located properly and the work clamped securely enough to prevent movement, but not tight enough to spring or distort the work. The correct clamping procedure is illustrated in Fig. 5A. Note that the step or packing block is slightly higher than the work and the bolt is located close to the work piece so that the main pressure is applied to the work.



**FIGURE 5A: Correct Clamping Procedure.** Block is higher than piece being clamped

Figure 5B illustrates an incorrect clamping procedure in which most of the pressure is applied to the step or packing block. Incorrect clamping occurs whenever the step or packing block is lower than the part being clamped, or when the bolt is closer to the block than to the work.



**FIGURE 5B: Incorrect Clamping Procedure.** Block is lower than piece being clamped

**Read it all**

When we look at diagrams, charts or tables, we need to refer back to *the guidance of the text*. The text tells us when to refer to the diagram and directs us to specific aspects of a drawing.

The text in Passage 2 directs you to Figure 5A in the third sentence. Next, the text directs your attention to a point on the diagram:

Note that the step or packing block is slightly higher than the work and the bolt is located close to the work piece.

Make sure you find the corresponding spot on the diagram. It is illustrated so that you can see it and understand it. You need to be sure that you are seeing exactly what you are supposed to see. The rest of the sentence gives you a reason for the placement described:

. . . so that the main pressure is applied to the work.

Figure 5B shows you incorrect clamping. After comparing correct and incorrect methods, you should be able to apply these directions. Further, the visual information should help you remember how to do this and why it's important to do it right.

### **Test yourself**

Assess how well you are interpreting diagrams. If we removed the references to the figures in the text in Passage 2 (e.g. Figure 5A and Figure 5B), could you do the following:

1. Match the text and diagrams correctly?
2. Identify which method of clamping is correct and which is incorrect?
3. Explain why the two methods differ? If it is not clear, read and then reread. Match diagram to text and text to diagram as you go. Find relevant spots on the diagram the way you would pick out points on a map.
4. Compare the two diagrams while referring to the text?
5. Piece together possible consequences of incorrect clamping from information contained in the text and diagrams?

If you can answer yes to the questions above, you have correctly interpreted the information.

## ***PART IV INFORMATION IN TEXT AND DIAGRAMS***

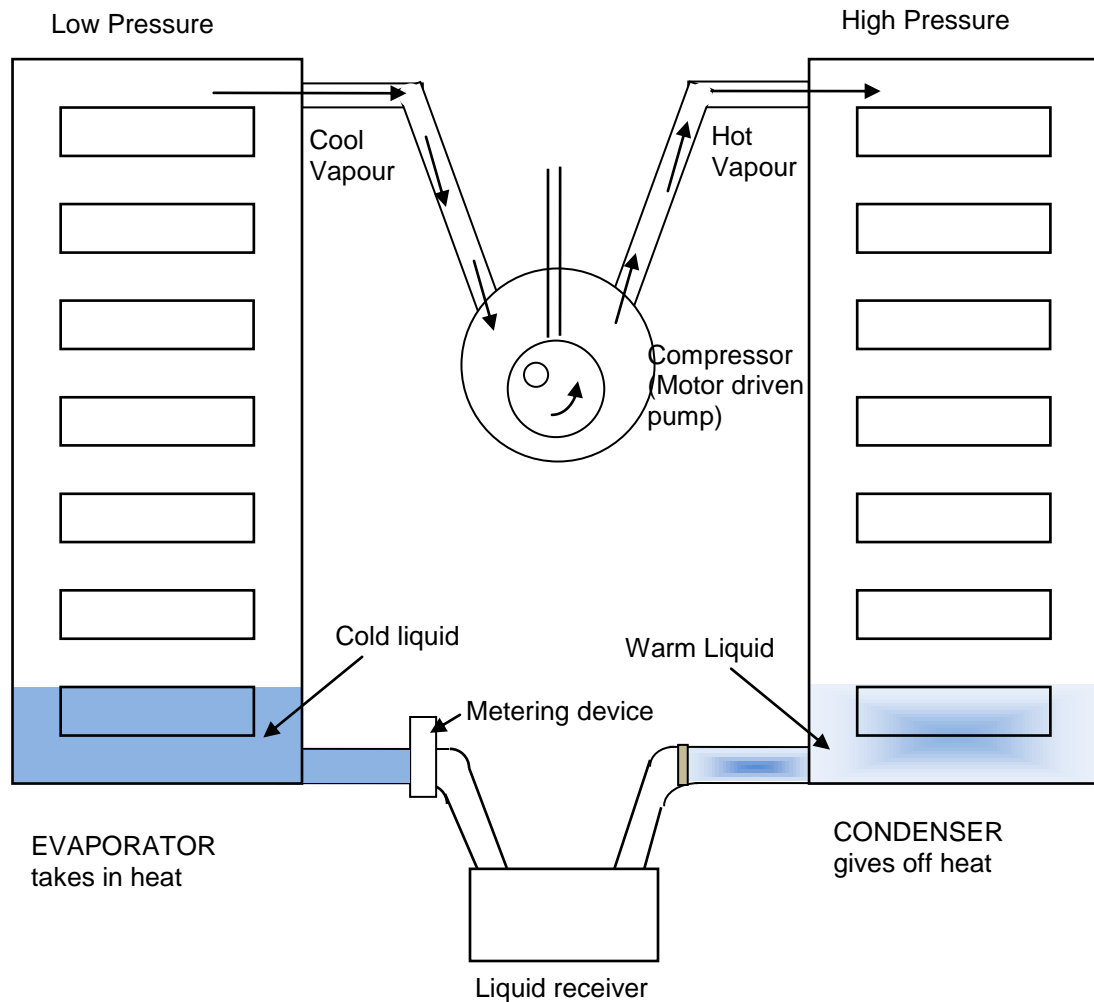
### **Stop and read the diagram**

A diagram relates to something real, whether it is a hydraulic circuit or the symbol for ducting on a blueprint. You need to be able to convert the information into language and later into actions. The first step is to understand what is being depicted by the diagram. Describe to yourself what the diagram represents. If you don't recognize certain symbols, look them up.

Read Passage 3 below and identify places or points on the diagram that correspond to the main text. The text explains what is happening; the diagram converts the written explanation into a visual representation.

#### **Passage 3 The Heat Pump**

A system used in refrigeration, air conditioning, and geo-thermal heating is shown in its essentials in Figure 6. The freezer compartment of an electric refrigerator (for household use) is an example of an evaporator. The chambers are double-walled and contain a liquid that evaporates very readily. This works much like the cooling that takes place when liquids such as gasoline, cleaning solvents or water evaporate from your hands. The faster the liquid evaporates, the cooler the effect; in other words, heat is removed at a quicker rate.



**FIGURE 6:** A Heat Pump

When the insides of a refrigerator warm a little, a thermostat activates an electric motor that runs a compressor (pump). The pump moves vapour away from the liquid in the evaporator. As a result more liquid is allowed to evaporate. As the liquid evaporates, it draws heat from the metal evaporator and from everything nearby. The vapour which goes through the pump is warmed by compression. The now hot vapour, under pressure, is cooled in the condenser to the point where it changes to liquid. It now gives off the heat that it absorbed in the evaporator when it became vapour. The air in the room cools the condenser; that is, it draws heat from the condenser.

**Answer the questions below using information from both the text and diagram. Answers are at the end of the skills manual.**

1. The vapour will be at its warmest:
  - a) just before going through the pump.
  - b) just after going through the pump.
  - c) There is no difference.

- 
2. Which sequence of information is correct, A or B?
    - A
      - a) electric motor starts
      - b) vapour is pumped away from liquid in evaporator
      - c) more liquid evaporates
      - d) heat is withdrawn from evaporator
    - B
      - a) electric motor starts
      - b) liquid goes through pump
      - c) and is warmed by compression
      - d) under pressure it is cooled in condenser
  3. To make the device work as a house heater (that is to warm air inside the house), you would:
    - a) put evaporator in the house so it can warm air inside the house.
    - b) put condenser in the house so it can warm air inside the house.

## **CONCLUSION**

The text that accompanies a diagram is directly related to it. They are partners. Usually the main text explains in words the information you see in a diagram. It also directs you at the appropriate time to study the diagram. It tells you what you should look for in the diagram.

When you use the information from both text and graphics, you develop a better understanding of a principle, a procedure or a type of equipment. Use text and diagrams together to enrich your learning. They can clearly show you a complex idea in a small space.

When the text describes steps in a process and the diagram illustrates it, you can follow the information flow. Your eyes can move in all directions. You can *see* the information from different points in the process. You can interpret what is happening at different stages.

Technical diagrams and symbols transfer information. Provided you read carefully and interpret correctly, graphics can do any of the following in little space and at a glance:

- ◆ show relationships,
- ◆ make abstract ideas easier to understand,
- ◆ show you something invisible or hidden, and
- ◆ focus on and emphasize important aspects on information.

## **Summary**

1. **Symbols are a form of shorthand.** Understand what these symbols represent to understand the language of your trade. Note any differences between countries.
2. **Lines convey information.** Lines and symbols can show relationships, objects and processes.
3. **Diagrams (graphics) use a visual approach** to make technical information meaningful.
4. **Diagrams are clearly labeled** to identify parts and their relationships.

5. **The text and diagram are directly related to each other and work as partners.** Always use them together.
6. **Always read the description that accompanies each diagram.** They tell you what you are looking at and what to look for.
7. **Diagrams and symbols relate to something you need to know.** Interpret and connect them to achieve understanding.

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**ANSWER PAGE**

**PART IV Passage 3 and Figure 6, Heat Pump**

1. The vapour will be at its warmest:  
b) just **after** going through the pump.

The text states that, "The vapour which goes through the pump is warmed by compression. The now hot vapour, under pressure, gets cooled in the condenser to the point. . ." The vapour is described as being **hot** as it is warmed by compression – not before compression.

The diagram makes this clearer: the vapour (top left) is **cool**. After going through the pump, it is **hot**.

2. Which sequence of information is correct, **A** or **B**?  
**A**

- a) electric motor starts
- b) vapour is pumped away from liquid in evaporator
- c) more liquid evaporates
- d) heat is withdrawn from evaporator

The text provides this in the same sequence. The diagram shows the changing states of liquid to vapour and shows with arrows the flow of vapour. No liquid goes through the pump.

3. To make the device work as a house heater (that is to warm air inside the house), you would  
b) put condenser in the house so it can warm air inside the house.

The text states, "The now hot vapour, under pressure, gets cooled in the condenser to the point where it changes again to liquid. It now **gives off the heat that it absorbed in the evaporator**. . . The air of the room cools the condenser; **that is, it draws heat from the condenser.**"

The diagram shows this very simply. The word CONDENSER clearly labels the drawing of a condenser and clearly states below GIVES OFF HEAT.