

Chapter 7

Manufacturing Processes

Learning Objectives

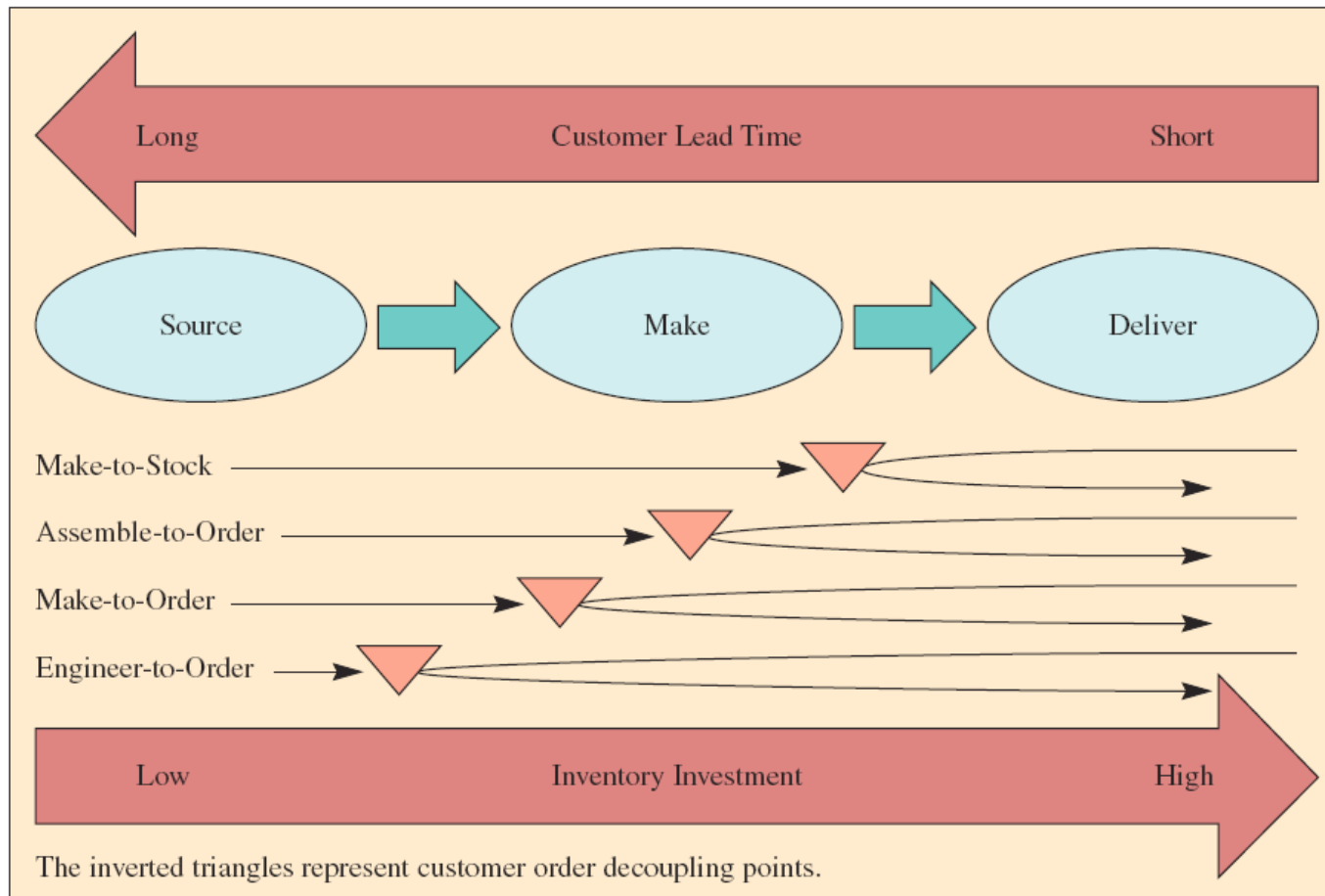
- 7-1: Understand what a manufacturing process is.
- 7-2: Explain how manufacturing processes are organized.
- 7-3: Analyze simple manufacturing processes.

What Are Production Processes?

(1 of 2)

- Production processes are used to make any manufactured item
- High level view can be divided into three steps
 - Step 1 – Source the parts needed
 - Step 2 – Make the product
 - Step 3 – Deliver the product

Exhibit 7.1 What Are Production Processes? (2 of 2)



Production Process Terms

- Lead time
 - The time needed to respond to a customer order
- Customer order decoupling point
 - Where inventory is positioned to allow entities in the supply chain to operate independently
- Lean manufacturing
 - A means of achieving high levels of customer service with minimal inventory investment

Types of Firms

- Make-to-Stock
 - Serve customers from finished goods inventory
- Assemble-to-Order
 - Combine a number of preassembled modules to meet a customer's specifications
- Make-to-Order
 - Make the customer's product from raw materials, parts, and components
- Engineer-to-Order
 - Work with the customer to design and then make the product

Make-to-Stock (1 of 2)

- Examples of products include the following:
 - Televisions
 - Clothing
 - Packaged food products
- Essential issue in satisfying customers is to balance the level of inventory against the level of customer service
 - Easy with unlimited inventory, but inventory costs money
 - Trade-off between the costs of inventory and level of customer service must be made

Make-to-Stock (2 of 2)

- Use lean manufacturing to achieve higher service levels for a given inventory investment

Assemble-to-Order

- A primary task is to define a customer's order in terms of alternative components because these are carried in inventory
 - An example is the way Dell Computer makes their desktop computers
- One capability required is a design that enables as much flexibility as possible in combining components
- There are significant advantages from moving the customer order decoupling point from finished goods to components

Make-to-Order/Engineer-to-Order

- Boeing's process for making commercial aircraft is an example
- Customer order decoupling point could be in either raw materials at the manufacturing site or the supplier inventory
- Depending on how similar the products are, it might not even be possible to preorder parts

How Production Processes Are Organized (1 of 2)

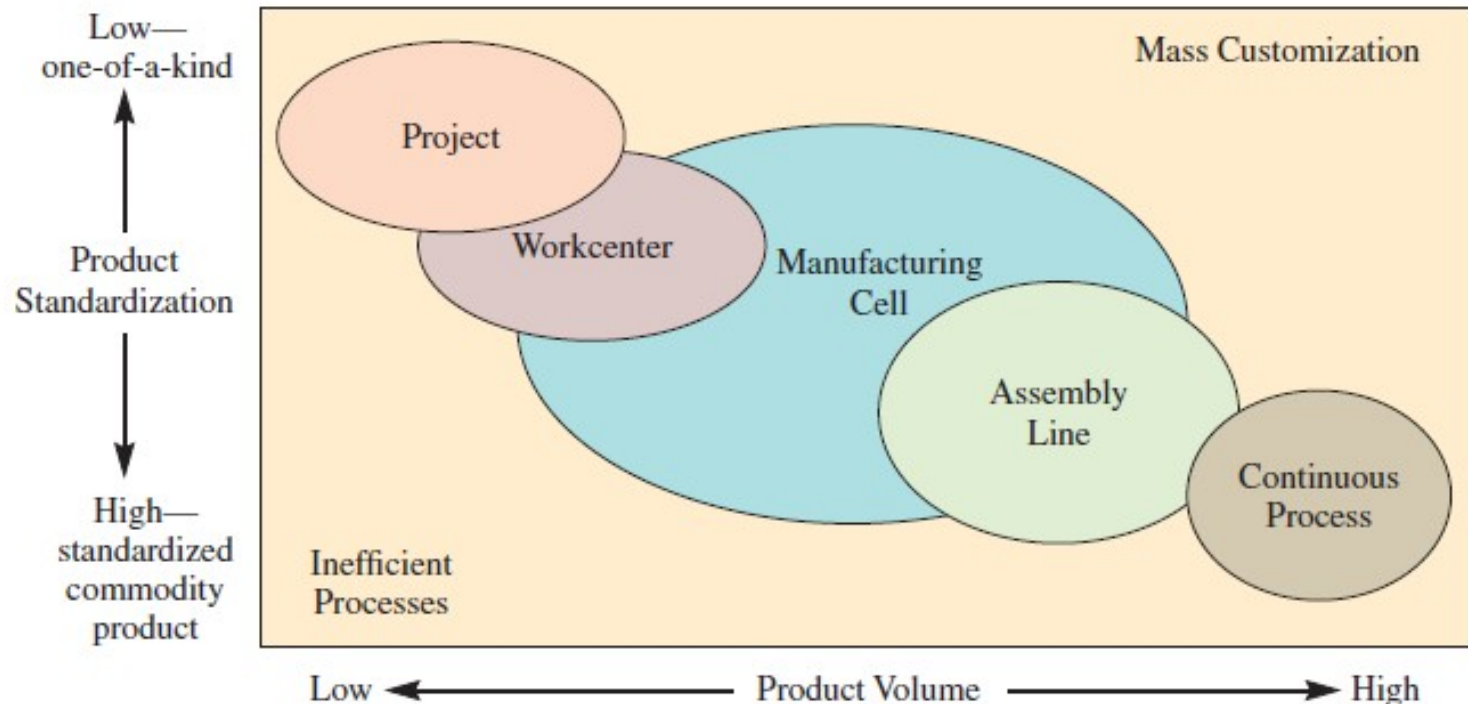
- Project
 - The product remains in a fixed location
 - Manufacturing equipment is moved to the product
- Work center (job shop)
 - Similar equipment or functions are grouped together
- Manufacturing cell
 - A dedicated area where products that are similar in processing requirements are produced

How Production Processes Are Organized (2 of 2)

- Assembly line
 - Work processes are arranged according to the progressive steps by which the product is made
- Continuous process
 - Assembly line only the flow is continuous such as with liquids

Product-Process Matrix: Framework Describing Layout Strategies

Exhibit 7.2



Production System Design (1 of 3)

- Project Layout
 - The product remains in a fixed location
 - A high degree of task ordering is common
 - A project layout may be developed by arranging materials according to their assembly priority

Production System Design (2 of 3)

- Workcenter
 - Most common approach to developing this type of layout is to arrange workcenters in a way that optimizes the movement of material
 - Optimal placement often means placing work centers with large interdepartmental traffic adjacent to each other
 - Sometimes is referred to as a department and is focused on a particular type of operation

Production System Design (3 of 3)

- Manufacturing Cell
 - Formed by allocating dissimilar machines to cells that are designed to work on similar products (shape, processing, etc.)
- Assembly Line and Continuous Layout
 - Designed for the special purpose of building a product by going through a series of progressive steps

Break-Even Analysis (1 of 2)

- Defined as standard approach to choosing among alternative processes or equipment
- Model seeks to determine the point in units produced where a company will start making profit on the process
- Model seeks to determine the point in units produced where total revenue and total cost are equal

Break-Even Analysis (2 of 2)

$$\text{Breakeven demand} = \frac{\text{Purchase cost of process or equipment}}{\text{Price per unit} - \text{Cost per unit}}$$

or

$$\text{Breakeven demand} = \frac{\text{Total fixed costs of process or equipment}}{\text{Unit price to customer} - \text{Variable cost per unit}}$$

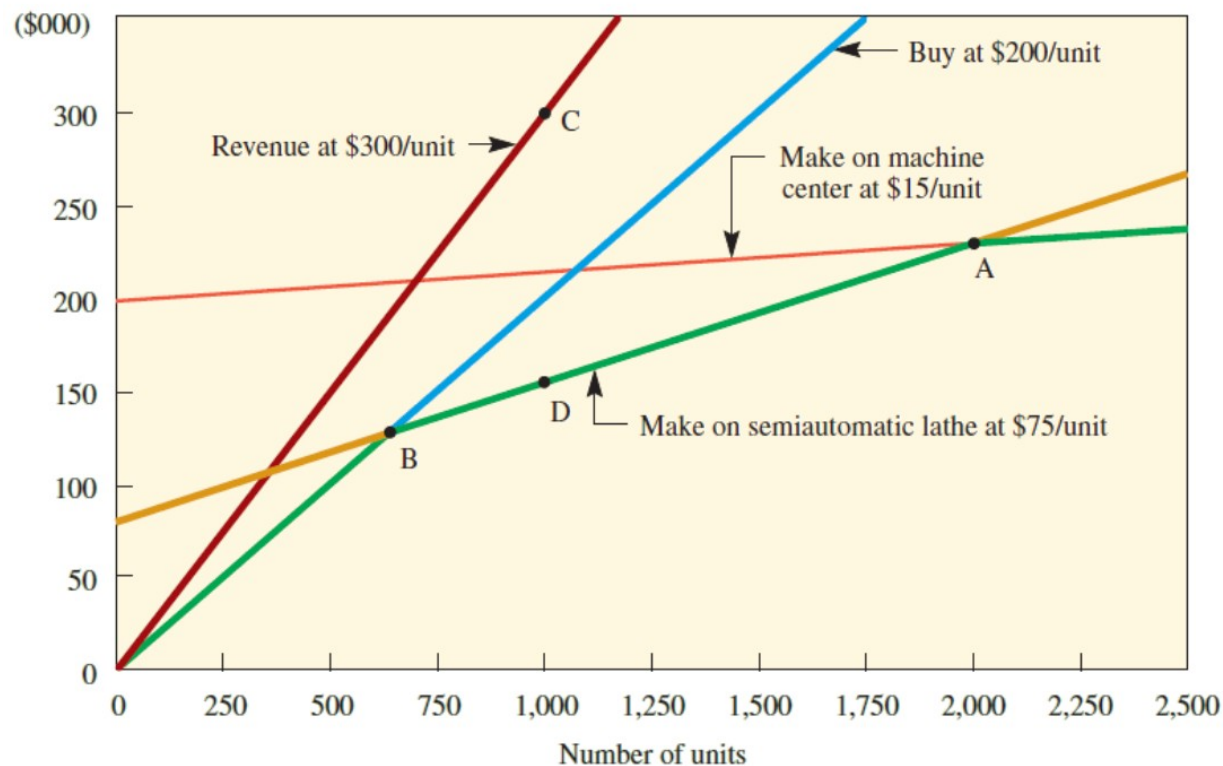
Example 7.1: Break-Even Analysis

- Buy for \$200
- Make on lathe for \$75
- Make on machining center for \$15
- Buy has no fixed costs
- Lathe has \$80,000 fixed costs
- Machining center has \$200,000 fixed costs

Example 7.1: Total Cost for Each Option

- Purchase
 - $\text{Cost} = \$200 \times \text{Demand}$
- Produce Using Lathe
 - $\text{Cost} = \$80,000 + \$75 \times \text{Demand}$
- Produce Using Machining Center
 - $\text{Cost} = \$200,000 + \$15 \times \text{Demand}$

Exhibit 7.3 Example 7.1: Costs Shown Graphically



Example 7.1: Finding Points A and B

Point A

$$\$80,000 + \$75 \cdot \text{Demand} = \$200,000 + \$15 \cdot \text{Demand}$$

$$\$80,000 + \$60 \cdot \text{Demand} = \$200,000$$

$$\$60 \cdot \text{Demand} = \$120,000$$

$$\text{Demand} = \$120,000 / \$60 = 2,000$$

Point B

$$\$200 \cdot \text{Demand} = \$80,000 + \$75 \cdot \text{Demand}$$

$$\$125 \cdot \text{Demand} = \$80,000$$

$$\text{Demand} = \$80,000 / \$125 = 640$$

Manufacturing Process Flow Design (1 of 2)

- **Manufacturing process flow design:** a method to evaluate the specific processes that material follow as they move through the plant
 - Common tools are assembly drawings, assembly charts, route sheets, and flow process charts

Manufacturing Process Flow Design (2 of 2)

- Focus should be on the identification of activities that can be minimized or eliminated
 - Movement and storage
 - The fewer the moves, delays, and storage, the better the flow

The Charts

- Assembly drawing
 - An exploded view of the product showing its component parts
- Assembly chart
 - Defines how parts go together, their order of assembly, and overall flow pattern
- Operation and route sheet
 - Specifies operations and process routing
- Process flowchart
 - Denotes what happens to the product as it progresses through the production facility

Exhibit 7.4 Sample Assembly Drawing

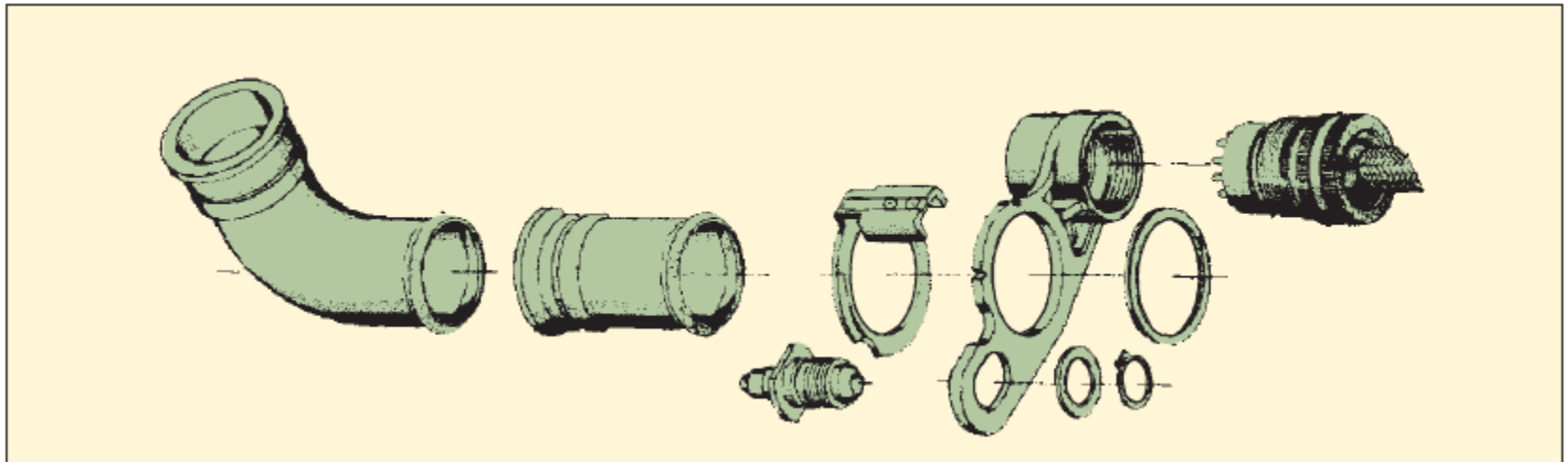


Exhibit 7.5 Sample Assembly Chart

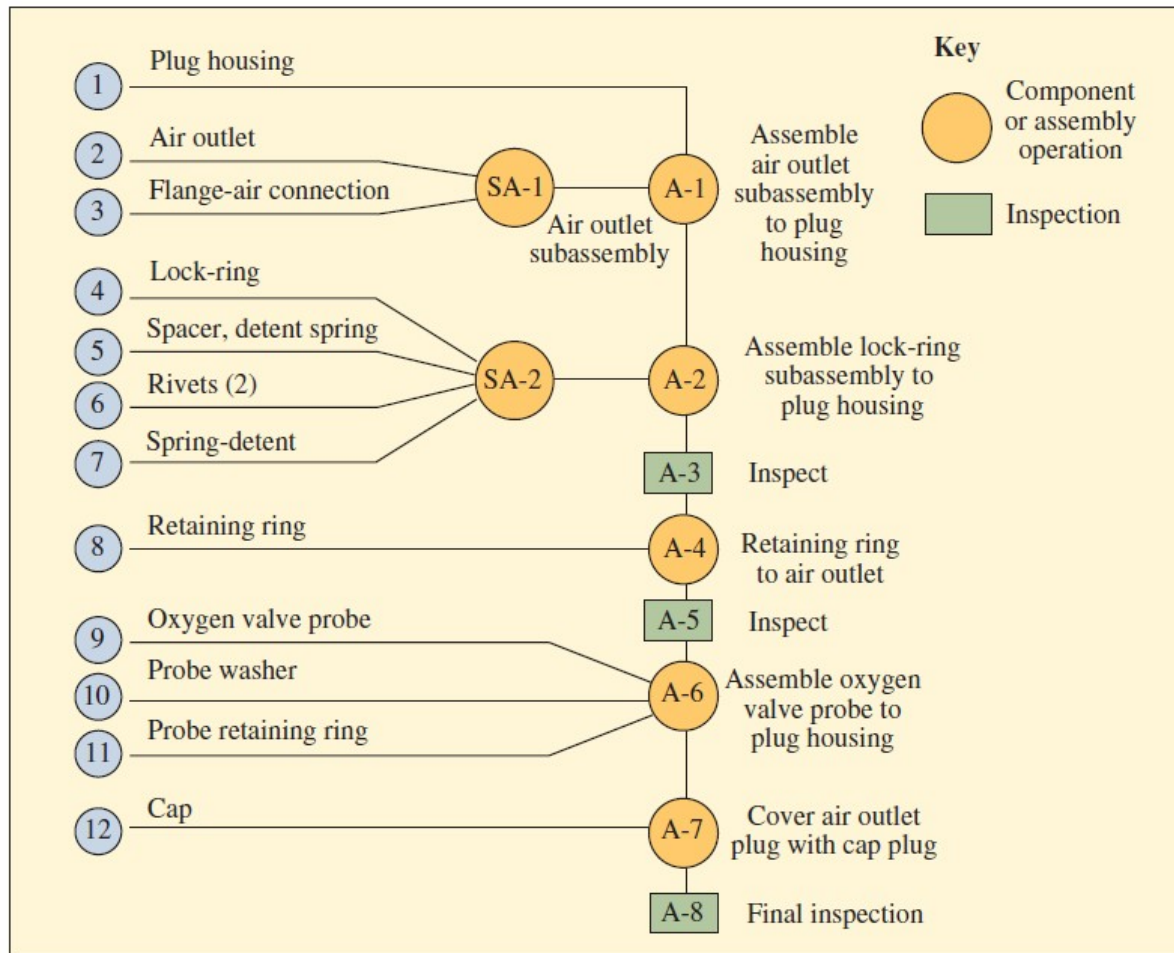
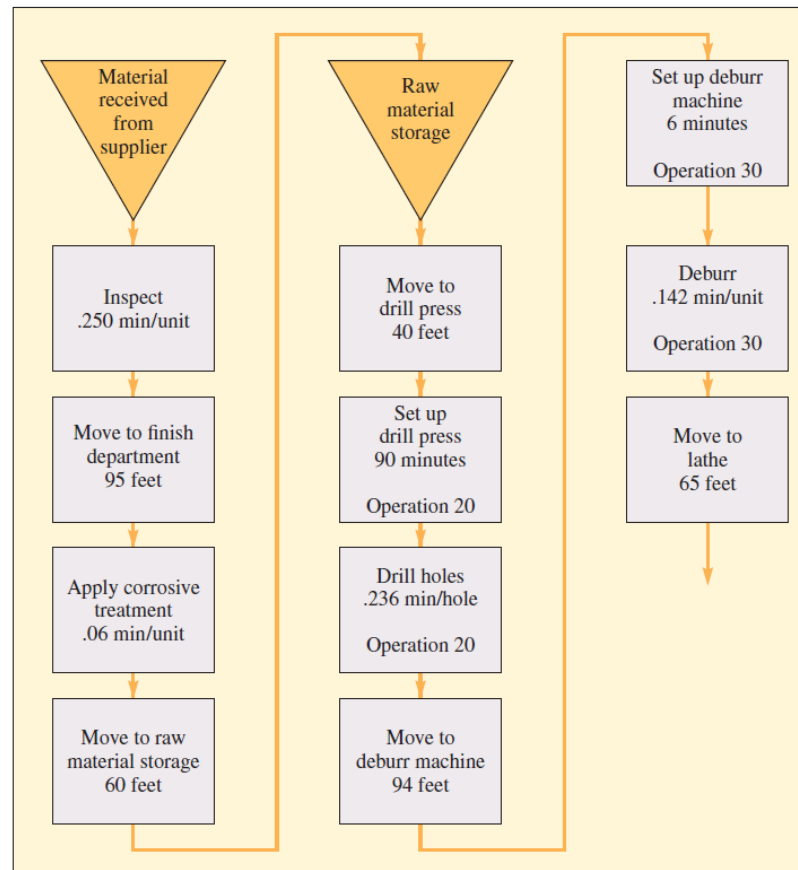


Exhibit 7.6 Sample Operation and Route Sheet

Material Specs _____		Part Name _____ Plug Housing		Part No. _____ TA 1274		
Purchased Stock Size _____		Usage _____ Plug Assembly		Date Issued _____		
Pcs. Per Pur Size _____		Assy. No. _____ TA 1279		Date Supplied _____		
Weight _____		Sub.Assy. No. _____		Issued By _____		
Oper. No.	Operation Description	Dept.	Machine	Setup Hr.	Rate Pc. Hr.	Tools
20	Drill hole .32 $\begin{smallmatrix} +.015 \\ -.005 \end{smallmatrix}$	Drill	Mach. 513 Drill	1.5	254	Drill fixture L-76 Jig # 10393
30	Deburr .312 $\begin{smallmatrix} +.015 \\ -.005 \end{smallmatrix}$ dia. hole	Drill	Mach. 510 Drill	.1	424	Multitooth burring tool
40	Chamfer .009/.875, bore .878/.875 dia (2 passes), bore .7600/.7625 (1 pass)	Lathe	Mach. D 109 lathe	1.0	44	Ramet-1, TPG 221, chamfer tool
50	Tap hole as designated 1/4 min. full thread	Tap	Mach. 517 drill tap	2.0	180	Fixture #CR-353 tap. 4 Flute sp.
60	Bore hole 1.33 to 1.138 dia.	Lathe	H&H E107	3.0	158	L44 turret fixture Hartford
						Superspacer, pl. #45 holder #L46
						FDTW-100, insert #21 chk. fixture
70	Deburr .005 to .010 both sides, hand feed to hard stop	Lathe	E162 lathe	.3	175	Collect CR #179 1327 RPM
80	Broach keyway to remove thread burrs	Drill	Mach. 507 drill	.4	91	B87 fixture, L59 broach tap. .875120 G-H6
90	Hone thread I.D. .822/ .828	Grind	Grinder	1.5	120	
95	Hone .7600/ .7625	Grind	Grinder	1.5	120	

Exhibit 7.7 Sample Flowchart



Example 7.2: Manufacturing Process Analysis

- 15 workers, eight-hour shift
- Assembly line moves at the rate of 150 components per hour
- Incentive pay of 30¢ per good part
- Can hire 15 more workers for second shift if needed
- All but molding from outside vender

Example 7.2: Molding

- 11 Machines
 - One usually down
 - One operator per machine
- 25 parts per hour
- Paid 20¢ per good part
- Overtime is 30¢ per part
- Employment is flexible
 - Currently 6 employees
 - 4 more available

Example 7.2: Remaining Costs

- Raw materials are 10¢ per part
- Electricity is 2¢ per part
- Purchased parts cost 30¢ per component
- Other weekly expenses
 - Rent is \$100
 - Other employees receive \$1,000
 - Accounting depreciation is \$50

Example 7.2: Questions to Answer

- a) Determine the capacity of the process
 - Are the capacities balanced?
- b) If the molding process were to use 10 machines instead of 6, what would be the capacity of the entire process?
- c) If the company went to a second shift, what would be the new capacity?
- d) Determine the cost per unit output when the capacity is 6,000 per week or 10,000 per week

Example 7.2: (a) Capacity of Entire Process

- Molding Capacity
 - 6 machines x 25 parts per week x 8 hours x 5 days = 6,000
- Assembly Capacity
 - 150 components per hour x 8 hours x 5 days = 6,000
- The capacities are balanced

Example 7.2: (b) Increasing Molding to 10 Machines

- Molding Capacity
 - **10** x 25 x 8 x 5 = 10,000
- Assembly capacity has not changed from 6,000
- The capacities are no longer balanced

Example 7.2: (c) Increasing Assembly Capacity

- Molding Capacity
 - $10 \times 25 \times 8 \times 5 = 10,000$
- Assembly Capacity
 - $150 \times \mathbf{16} \times 5 = 12,000$
- New capacity is 10,000

Example 7.2: (d) Cost for 6,000 Parts per Week

ITEM	CALCULATION	COST
Raw material for molding	\$0.10 per part × 6,000=	\$ 600
Parts purchased from outside	\$0.30 per component × 6,000=	1,800
Electricity	\$0.02 per part × 6,000=	120
Molding labor	\$0.20 per part × 6,000=	1,200
Assembly labor	\$0.30 per part × 6,000=	1,800
Rent	\$100 per week	100
Supervision	\$1,000 per week	1,000
Depreciation	\$50 per week	50
Total cost		\$6,670

$$\text{Cost per unit} = \frac{\text{Total cost per week}}{\text{Number of units produced per week}} = \frac{\$6,670}{6,000} = \$1.11$$

Example 7.2: (d) Cost for 10,000 Parts per Week

ITEM	CALCULATION	COST
Raw material for molding	\$0.10 per part × 10,000=	\$ 1,000
Parts purchased from outside	\$0.30 per component × 10,000=	3,000
Electricity	\$0.02 per part × 10,000=	200
Molding labor	\$0.20 per part × 10,000=	2,000
Assembly labor	\$0.30 per part × 10,000=	3,000
Rent	\$100 per week	100
Supervision	\$1,000 per week	1,000
Depreciation	\$50 per week	50
Total cost		\$ 10,350

$$\text{Cost per unit} = \frac{\text{Total cost per unit}}{\text{Number of units produced per week}} = \frac{\$10,350}{10,000} = \$1.04$$

Summary(1 of 2)

- Manufacturing processes are used to make tangible items
 - Sourcing parts, making the item, sending it to the customer
- To allow parts of the process to operate independently, inventory is strategically positioned in the process
- Positioning the decoupling points has an impact on speed, flexibility, and many other trade-offs

Summary(2 of 2)

- Manufacturing layouts are designed based on the nature of the product, the volume needed to meet demand, and the cost of equipment
- Break-even analysis is useful for understanding the cost trade-offs between alternative equipment choices
- Visual charts can be used to document manufacturing process flows
- Flowcharts provide a simple but insightful analysis of capacity and variable cost

Practice Exam (1 of 2)

1. A firm that makes predesigned products directly to fill customer orders has this type of production environment
2. A point where inventory is positioned to allow the production process to operate independently of the customer order delivery process
3. A firm that designs and builds products from scratch according to customer specifications would have this type of production environment

Practice Exam (2 of 2)

4. If a production process makes a unit every two hours and it takes 42 hours for the unit to go through the entire process, what is the expected work-in-process equal to
5. This is a production layout where similar products are made. Typically, it is scheduled on an as-needed basis in response to current customer demand
6. The relationship between how different layout structures are best suited depending on volume and product variety characteristics is depicted on this type of graph

End of Presentation