CHAPTER

7

Special Production Issues: Lost Units and Accretion

LEARNING OBJECTIVES

After completing this chapter, you should be able to answer the following questions:

1
What is an accepted quality level and how does it relate to zero tolerance for errors and defects?

2
Why do lost units occur in manufacturing processes?

3
How do normal and abnormal losses of units differ and how is each treated in an EUP schedule?

4
How are the costs of each type of loss assigned?

5
How are rework costs of defective units treated?

6
How are losses treated in a job order costing system?

7
How does accretion of units affect the EUP schedule and costs per unit?

8
What is the cost of quality products?

INTRODUCING

General Electric Company

http://www.ge.com

Thomas Alva Edison invented the first successful incandescent light bulb in 1879. Shortly thereafter, General Electric (GE) began providing power and lighting up America and the world. General Electric Company was formed in 1892 through a merger of Edison Electric Light Company and Thomson-Houston Company.

Today, GE is the world's largest diversified services company as well as a provider of high-quality, high-technology industrial and consumer products. While maintaining world-class leadership in its beginnings in providing power systems and electric lighting, the company has expanded into many areas. A few examples include aircraft engines, medical systems, financial services, television broadcasting, and transportation systems. GE consists of more than three dozen businesses operating in 100 companies around the globe. Although widely diverse, GE businesses are also highly familial and share information, resources, technology, and intellectual capital.

GE's sharing among all its businesses includes:

1. a common operating system and a social architecture characterized by boundaryless behavior,
2. a common leadership development system,
3. one set of common values, and
4. four common initiatives—globalization, product services, e-business, and Six Sigma quality.

Six Sigma is a quality management term used to define a process for eliminating variation and, therefore, eliminating defects. Statistically, Six Sigma quality means improving manufacturing quality to six standard deviations from the specification limit. This translates to a rate of 3.4 defects out of a million items processed. GE is absolutely committed to delivering flawless products and services to its customers.

At GE, the Six Sigma initiative is in its fifth year—its fifth trip through the operating system. From a standing start in 1996, with no financial benefit to the company, it has flourished to the point where it provided more than $2 billion in benefits in 1999, with much more to come this decade.

SOURCES: General Electric Company Web site, http://www.ge.com (June 2000); Robert Buderi, "The Six Sigma Approach Revs Up," *Upside* (May 2000), p. 50.

Unlike the General Electric (GE) processes that have been subjected to zero-defect tolerance, most companies tolerate some level of defects by establishing an **accepted quality level (AQL)** for their production or service processes. AQL is the maximum limit for the number of defects or errors in a process. If the percentage of defects or errors is less than the AQL, the company considers that it has performed at an acceptable quality level.

1

What is an accepted quality level and how does it relate to zero tolerance for errors and defects?

accepted quality level (AQL)

Companies viewed as having world-class status in a particular endeavor seek to continuously tighten the accepted quality level. Thus, producing goods with zero defects and performing services with zero errors are laudable goals and ones toward which domestic and foreign companies are striving.

The examples in Chapter 6 assumed that all units to be accounted for have either been transferred or are in ending work in process inventory; however, almost every process produces some units that are spoiled or do not meet production specifications. Phenomena in the production process also may cause the total units accounted for to be less than the total units to account for. In other situations (unrelated to spoiled units), the addition or expansion of materials after the start of the process may cause the units accounted for to be greater than those to be accounted for originally or in a previous department.

This chapter covers these more complex issues of process costing. Spoiled and defective units, reworking of defective units, and accretion require adjustments to the equivalent units of production (EUP) schedule and cost assignments made at the end of a period. The last section of this chapter discusses controlling quality so that only a minimal number of inferior goods are produced.

LOSS OF UNITS

2

Why do lost units occur in manufacturing processes?

shrinkage

http://www.starbucks.com
http://www.siratechnologies.com

Few, if any, processes combine material, labor, and overhead with no loss of units. Some of these losses, such as evaporation, leakage, or oxidation, are inherent in the production process. For example, when Starbucks roasts coffee beans, approximately 20 percent of the original weight is lost from water evaporation. This situation results in **shrinkage**. Modifying the production process to reduce or eliminate the causes of shrinkage may be difficult, impossible, or simply not cost beneficial.

Spoilage of some food products occurs simply by exposure to the atmosphere wherever perishable foods are processed or stored. In this regard, Louisiana State University and SIRA Technologies have developed a new monitoring system for meat that can enable meat processors and food retailers to better regulate the safety requirements for storage and prevent loss of reputation and revenue from selling meat containing harmful bacteria. The technology uses a bar code treated with antibodies that are sensitive to virulent strains of bacteria.[1] As discussed in the accompanying News Note, spoilage of meats and other perishable foods awaiting customer purchases in supermarkets can be further prevented by covering refrigeration cases each night.

At other times, errors in the production process (either by humans or machines) cause a loss of units through rejection at inspection for failure to meet appropriate quality standards or designated product specifications. Whether these lost units are

NEWS NOTE — QUALITY

Closing the Curtain on Contaminants

It is estimated that 75% of the supermarkets in North America are closed to the public for 6 to 8 hours at night. With little effort, these supermarkets could claim dollars that are lost during the stores' closed hours from unnecessary energy consumption and premature spoilage of many perishable products.

Open refrigerated display cases are the best way for retailers to present fresh merchandise to consumers. Unfortunately, these cases are also open to the effects of heat and UV radiation from the store environment.

There is often a misconception that the refrigerated air escapes from the display case. However, heat or warm air is actually drawn toward the colder air, raising the temperatures in the display case; this causes merchandise to warm up and compressors to operate more frequently.

More frequent compressor operation and exposed products must be tolerated so that consumers can shop freely, but when the store is closed, simple steps can be taken to reduce store energy consumption and extend product shelf life with ideal cold temperatures.

To solve this problem, an efficient temperature barrier is needed between the opening of the display case and the store interior. The ideal thermal barrier arrangement must have several qualities to be effective in increasing store profit:

- Reasonable cost and quick initial payback period;
- Simple and quick to put in operation;
- No interference with customer access to fresh merchandise when the store is open;
- No disturbance to the cosmetic appearance of the store;
- Durable commercial quality;
- Hygienic (will not rust or attract dust, mold, and mildew);
- Simple, quick cleaning maintenance that can be done when cleaning the case; and
- Effective in the reflection of heat and UV radiation.

A vertical rolling curtain permanently attached to the top of the display was agreed upon as the simplest and easiest to use arrangement. To adapt to this arrangement, a 99% pure aluminum heat-reflective fabric was developed. To provide strength to the woven aluminum fabric and eliminate oxidation, it is coated with a thin, transparent film.

SOURCE: Staff, "The Big Cover-Up in the Refrigeration Case," *Air Conditioning, Heating, and Refrigeration News* (April 3, 2000), pp. 27ff.

[1] Ginger Koloszyc, "New Bar-Code Technology Detects Meat Spoilage," *Stores* (October 1998), p. 72.

considered defective or spoiled depends on their ability to be economically reworked. **Economically reworked** means that (1) the unit can be reprocessed to a sufficient quality level to be salable through normal distribution channels and (2) incremental rework cost is less than incremental revenue from the sale of reworked units. A **defective unit** can be economically reworked, but a **spoiled unit** cannot. An inspector in the company making the product determines which are defective and which are spoiled.

economically reworked

defective unit

spoiled unit

To illustrate the difference between defective and spoiled units, assume you order blackened redfish at a restaurant. You are now the control inspector. If the redfish brought to you is barely blackened, it is a defective unit because the chef can cook it longer to bring it up to "product specifications." The incremental revenue is the selling price of the redfish; the incremental cost is a few moments of the chef's time. However, if the fish brought to you is blackened to a cinder, it is a spoiled unit because it cannot be reworked. Therefore, a newly cooked blackened redfish would have to be provided.

3

How do normal and abnormal losses of units differ and how is each treated in an EUP schedule?

A **normal loss** of units falls within a tolerance level expected during production. Management creates a range of tolerance of spoiled units specified by the accepted quality level, as mentioned in the beginning of this chapter. If a company had set its quality goal as 98 percent of goods produced, the company would have been expecting a normal loss of 2 percent. Any loss in excess of the AQL is an **abnormal loss**. Thus, the difference between normal and abnormal loss is merely one of degree and is determined by management.

normal loss

abnormal loss

A variety of methods can be used to account for units lost during production. Selection of the most appropriate method depends on two factors: (1) the cause of the decrease and (2) management expectations regarding lost units. Understanding why units decreased during production requires detailed knowledge of the manufacturing process. Management's expectations are important to determine the acceptable loss quantities from defects, spoilage, or shrinkage as well as the revenue and cost considerations of defective and spoiled units.

TYPES OF LOST UNITS

In developing the product design, manufacturing process, and product quality, management selects a combination of material, labor, and overhead from the wide resource spectrum available. This combination is chosen to provide the lowest long-run cost per unit and to achieve the designated product specifications—including those for quality. In making this resource combination choice, managers recognize that, for most combinations, some degree of production error may occur that will result in lost units. Given the resource choices made by management, the quantity or percentage of lost units to be generated in a given period or production run should be reasonably estimable. This estimate is the normal loss because it is planned for and expected. Normal loss is usually calculated on the basis of good output or actual input.

Some companies may estimate the normal loss to be quite high because the lowest cost material, labor, or overhead support is chosen. For example, assume that Scrape Manufacturing Ltd. chooses to install the least advanced, lowest cost machinery for production purposes because its workers do not have the educational or technological skills to handle the more advanced equipment. The installed equipment may have fewer quality checks and, thus, produce more spoiled units than the more advanced equipment. Scrape's managers have decided that the costs of upgrading worker skills were greater than the cost of lost units.

Another reason for high estimated normal losses relates not to the resources chosen, but to a problem inherent in the product design or in the production process. In other cases, based on cost-benefit analysis, managers may find that a problem would cost more to eliminate than to tolerate. For example, assume a machine malfunctions once every 100 production runs and improperly blends ingredients. The machine processes 50,000 runs each year and the ingredients in each run cost $10. Correcting the problem has been estimated to cost $20,000 per year. Spoilage cost is $5,000 per year (500 spoiled batches × $10 worth of ingredients) plus a minimal amount of overhead costs. If company employees are aware of the malfunction and catch every improperly blended run, accepting the spoilage is less expensive than correcting the problem.

If, alternatively, the spoiled runs are allowed to leave the plant, they may create substantial quality failure costs in the form of dissatisfied customers and/or salespeople who might receive the spoiled product. Managers in world-class companies should be aware that the estimate of the cost to develop a new customer is $50,000, five times as much as the estimated cost of keeping an existing one.[2] In making their cost-benefit analysis, managers must be certain to quantify all the costs (both direct and indirect) involved in spoilage problems.

An abnormal loss is a loss in excess of the normal, predicted tolerance limits. Thus, when an abnormal loss occurs, so does a normal loss (unless zero defects have been set as the AQL). Abnormal losses generally arise because of human or machine error during the production process. For example, if the tolerances on one of a company's production machines were set incorrectly, a significant quantity of defective products might be produced before the error was noticed. Because abnormal losses result from nonrandom, special adverse conditions and actions, they are more likely to be preventable than some types of normal losses.

Realistically, units are lost in a production process at a specific point. However, accounting for lost units requires that the loss be specified as being either continuous or discrete. For example, the weight loss in roasting coffee beans and the relatively continual breakage of fragile glass ornaments can be considered

continuous loss

continuous losses because they occur fairly uniformly throughout the production process.

discrete loss

In contrast, a **discrete loss** is assumed to occur at a specific point. Examples of discrete losses include adding the wrong amount of vinegar to a recipe for salad dressing or attaching a part to a motor upside down. The units are only deemed lost and unacceptable when a quality check is performed. Therefore, regardless of where in the process the units were truly "lost," the loss point is always deemed to be an inspection point. Thus, units that have passed an inspection point should be good units (relative to the specific characteristics inspected), whereas units that have not yet passed an inspection point may be good or may be defective/spoiled.

Control points can be either built into the system or performed by inspectors. The former requires an investment in prevention costs; the latter results in appraisal costs. Both are effective, but prevention is often more efficient because acceptable quality cannot be inspected into a product; it must be a part of the production process. Investments to prevent lost units may relate either to people or machines. (Prevention costs and appraisal costs are formally defined in Chapter 8.)

In determining how many quality control inspection points (machine or human) to install, management must weigh the costs of having more inspections against the savings resulting from (1) not applying additional material, labor, and overhead to products that are already spoiled or defective (direct savings) and (2) the reduction or elimination of internal and external failure costs (indirect savings). Quality control points should always be placed before any bottlenecks in the production system so that the bottleneck resource is not used to process already defective/spoiled units. Additionally, a process that generates a continuous defect/spoilage loss requires a quality control point at the end of production; otherwise, some defective/spoiled units would not be found and would be sent to customers, creating external failure costs. (Failure costs are formally defined in Chapter 8.)

[2] Peter L. Grieco, Jr., "World-Class Customers," *Executive Excellence* (February 1996), p. 10.

ACCOUNTING FOR LOST UNITS

4

How are the costs of each type of loss assigned?

The method of accounting for the cost of lost units depends on whether the loss is considered normal or abnormal and whether the loss occurred continuously in the process or at a discrete point. Exhibit 7–1 summarizes the accounting for the cost of lost units.

The traditional method of accounting for normal losses is simple. Normal loss cost is considered a product cost and is included as part of the cost of the good units resulting from the process. Thus, the cost of the loss is inventoried in Work in Process and Finished Goods Inventories and expensed only when the good units are sold. This treatment has been considered appropriate because normal losses have been viewed as unavoidable costs in the production of good units. If the loss results from shrinkage caused by the production process, such as the weight loss of roasting coffee beans, this treatment seems logical.

Alternatively, consider the company producing fragile scientific lenses: If the company allows for losses by virtue of the level at which some acceptable quality was set, then management will not receive valuable information about the cost of quality losses. In contrast, if the same company were to institute a zero-defect policy, there would by definition be no "normal" loss. All losses would be outside the tolerance specifications for acceptable quality.

The costs of normal shrinkage and normal *continuous* losses are handled through the **method of neglect**, which simply excludes the spoiled units in the equivalent units schedule. Ignoring the spoilage results in a smaller number of equivalent units of production (EUP) and, by dividing production costs by a smaller EUP, raises the cost per equivalent unit. Thus, the cost of lost units is spread proportionately over the good units transferred and those remaining in Work in Process Inventory.

method of neglect

Alternatively, the cost of normal, *discrete* losses is assigned only to units that have passed the inspection point. Such units should be good units (relative to the inspected characteristic), whereas the units prior to this point may be good or may be defective/spoiled. Assigning loss costs to units that may be found to be defective/spoiled in the next period would not be reasonable.

EXHIBIT 7–1

Continuous versus Discrete Losses

Type	Assumed to Occur	May Be	Cost Handled How?	Cost Assigned To?
Continuous	Uniformly throughout process	Normal	Absorbed by all units in ending inventory and transferred out on an EUP basis	Product
		or		
		Abnormal	Written off as a loss on an EUP basis	Period
Discrete	At inspection point or at end of process	Normal	Absorbed by all units past inspection point in ending inventory and transferred out on an EUP basis	Product
		or		
		Abnormal	Written off as a loss on an EUP basis	Period

Regardless of whether defects/spoilage occur in a continuous or discrete fashion, the cost of abnormal losses should be accumulated and treated as a loss in the period in which those losses occurred. This treatment is justified by the cost principle discussed in financial accounting. The cost principle allows only costs that are necessary to acquire or produce inventory to attach to it. All unnecessary costs are written off in the period in which they are incurred. Because abnormal losses are not necessary to the production of good units and the cost is avoidable in the future, any abnormal loss cost is regarded as a period cost. This cost should be brought to the attention of the production manager who should then investigate the causes of the loss to determine how to prevent future similar occurrences. Abnormal loss cost is always accounted for on an equivalent unit basis.

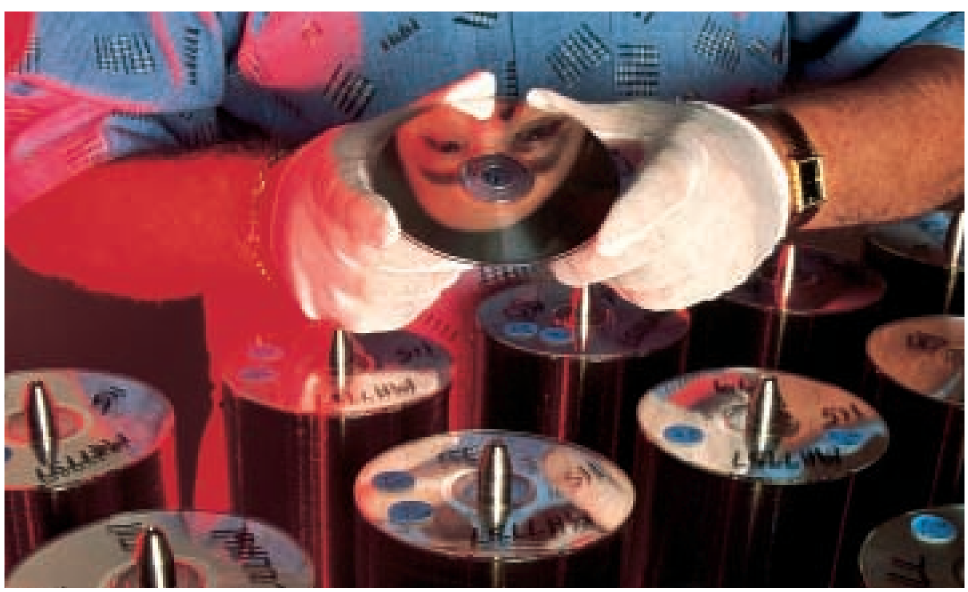
ILLUSTRATIONS OF LOST UNITS

To best understand how to account for a process that creates lost goods, it is helpful to know the answers to the following questions:

1. What is the process flow?
2. Where is material added during the process?
3. How are labor and overhead applied? (This answer is usually "Continuously," but not necessarily at the same rate.)
4. At what stage of completion was the beginning inventory and what is the ending inventory?
5. Where are the quality control inspection points?
6. How do defective/spoiled units occur? (Continuously or discretely?)

Impervious Inc. is used to illustrate several alternative situations regarding the handling of lost units in a process costing environment. Impervious produces a high-tech, very durable, nonfade (once color pigment is added) paint base material—hereafter simply referred to as paint—for appliances and equipment. The paint is produced in a single department and then sold to appliance and equipment manufacturers. All materials are added at the start of the process, and conversion costs are applied uniformly throughout the production process. Recyclable containers are provided by buyers and, therefore, are not a cost to Impervious. The company uses the FIFO method of calculating equivalent units.

Spoilage in the production of CD-ROMs can occur from a wide variety of causes and at numerous points in the production process. Because spoilage tends to be machine-related, quality checks are built into the production system and are often performed robotically. However, the final quality control analysis is performed by a replication operator.



Situation 1—Normal Loss Only; Loss Occurs Throughout Production Process (Continuous)

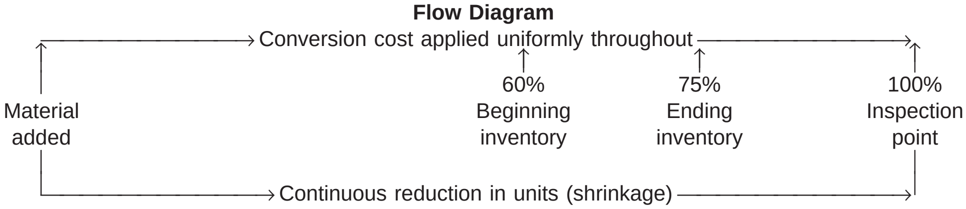
During processing, the paint is mechanically blended and cooked, resulting in a normal loss from shrinkage. Mechanical malfunctions sometimes occur and, when they do, cause some spoilage. Any decrease of 10 percent or less of the gallons placed into production for a period is considered normal. The April 2000 data for Impervious are given below:

GALLONS	
Beginning inventory (60% complete)	2,000
Started during month	15,000
Gallons completed and transferred	13,200
Ending inventory (75% complete)	2,500
Lost gallons (normal)	1,300

COSTS		
Beginning inventory:		
Material	$ 15,000	
Conversion	1,620	$ 16,620
Current period:		
Material	$102,750	
Conversion	19,425	
		122,175
Total costs		$138,795

To visualize the manufacturing process for Impervious, a flow diagram can be constructed. Such a diagram provides distinct, definitive answers to all of the questions asked at the beginning of this section.

Flow Diagram



The steps discussed in Chapter 6 on process costing are followed to determine the units accountable for, units accounted for, equivalent units of production, costs accountable for, cost per equivalent unit, and cost assignment. These steps are presented in the cost of production report shown in Exhibit 7–2.

The department is accountable for 17,000 gallons of paint: 2,000 gallons in beginning inventory plus 15,000 gallons started into processing during April. Only 15,700 gallons (13,200 completed and 2,500 in ending inventory) are accounted for prior to considering the processing loss. The 1,300 lost gallons are included in the schedule of gallons accounted for to balance to the total 17,000 gallons, but these gallons are not extended into the computation of equivalent units of production. Using the method of neglect, these gallons simply "disappear" in the EUP schedule. Thus, the cost per equivalent gallon of the remaining good production of the period is higher for each cost component.

Had the lost gallons been used in the denominator of the cost per EUP computation, the cost per EUP would have been smaller, and the material cost per unit would have been $6.85 ($102,750 ÷ 15,000). Because the lost units do not appear in the cost assignment section, their costs must be assigned only to good production. The use of the lower cost per EUP would not allow all of the costs to be accounted for in Exhibit 7–2.

EXHIBIT 7–2

Cost of Production Report for Month Ended April 30, 2000 (FIFO method) (Normal continuous shrinkage)

PRODUCTION DATA

		EQUIVALENT UNITS	
	Whole Units	Material	Conversion
Beginning inventory (100%; 60%)	2,000		
Gallons started	15,000		
Gallons to account for	17,000		
Beginning inventory completed (0%; 40%)	2,000	0	800
Gallons started and completed	11,200	11,200	11,200
Total gallons completed	13,200		
Ending inventory (100%; 75%)	2,500	2,500	1,875
Normal shrinkage	1,300		
Gallons accounted for	17,000	13,700	13,875

COST DATA

	Total	Material	Conversion
Beginning inventory costs	$ 16,620		
Current costs	122,175	$102,750	$19,425
Total costs	$138,795		
Divided by EUP		13,700	13,875
Cost per FIFO EUP	$8.90	$7.50	$1.40

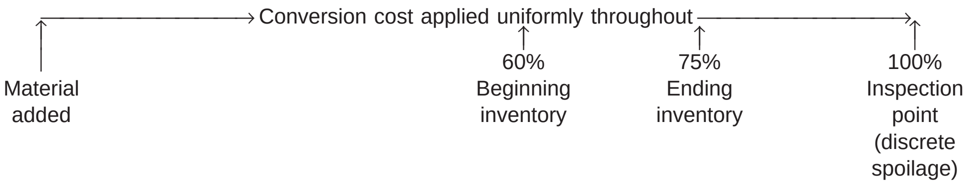
COST ASSIGNMENT

Transferred:		
Beginning inventory	$16,620	
Cost to complete: Conversion (800 × $1.40)	1,120	
Total cost of beginning inventory	$17,740	
Started and completed (11,200 × $8.90)	99,680	
Total cost of gallons transferred		$117,420
Ending inventory:		
Material (2,500 × $7.50)	$18,750	
Conversion (1,875 × $1.40)	2,625	21,375
Total costs accounted for		$138,795

Accounting for normal, continuous shrinkage (or defects/spoilage) is the easiest of the types of lost unit computations. There is, however, a theoretical problem with this computation when a company uses weighted average process costing. The units in ending Work in Process Inventory have lost unit cost assigned to them in the current period and will have lost unit cost assigned *again* in the next period. But, even with this flaw, this method provides a reasonable measure of unit cost if the rate of spoilage is consistent from period to period.

Situation 2—Normal Spoilage Only; Spoilage Determined at Final Inspection Point in Production Process (Discrete)

This example uses the same basic cost and unit information given above for Impervious Inc. except that no shrinkage occurs. Instead, the paint is inspected at the end of the production process. Any spoiled gallons are removed and discarded at inspection; a machine malfunction or an improper blending of a batch of paint usually causes spoilage. Any spoilage of 10 percent or less of the gallons placed into production during the period is considered normal. A production flow diagram is shown at the top of the next page.



In this situation, the spoiled gallons of product are included in the equivalent unit schedule. Because the inspection point is at 100 percent completion, all work has been performed on the spoiled gallons and all costs have been incurred to produce those gallons. By including the spoiled gallons at 100 percent completion in the EUP schedule, cost per gallon reflects the cost that *would have been incurred* had all production been good production.

Cost of the spoiled gallons is assigned solely to the completed units. Because ending Work in Process Inventory has not yet passed the inspection point, this inventory may contain its own normal spoilage, which will be detected next period. The cost of production report for Situation 2 is shown in Exhibit 7–3.

Situation 3—Normal Spoilage Only; Spoilage Determined During Production Process (Discrete)

In this example, Impervious Inc. inspects the paint when the conversion process is 50 percent complete. The only difference between this example and the previous one is that, for April, the ending Work in Process Inventory has passed the inspection point. Because of this difference, spoilage cost must be allocated to both the gallons transferred and to ending inventory. Although the ending inventory *could* become spoiled during the remainder of processing, it is either highly unlikely or the cost

EXHIBIT 7–3

Cost of Production Report for Month Ended April 30, 2000 (FIFO method) (Normal discrete spoilage)

PRODUCTION DATA		EQUIVALENT UNITS	
	Whole Units	Material	Conversion
Beginning inventory (100%; 60%)	2,000		
Gallons started	15,000		
Gallons to account for	17,000		
Beginning inventory completed (0%; 40%)	2,000	0	800
Gallons started and completed	11,200	11,200	11,200
Total gallons completed	13,200		
Ending inventory (100%; 75%)	2,500	2,500	1,875
Normal spoilage (100%; 100%)	1,300	1,300	1,300
Gallons accounted for	17,000	15,000	15,175

COST DATA	Total	Material	Conversion
Beginning inventory costs	$ 16,620		
Current costs	122,175	$102,750	$19,425
Total costs	$138,795		
Divided by EUP		15,000	15,175
Cost per FIFO EUP	$8.13	$6.85	$1.28

(continued)

EXHIBIT 7–3

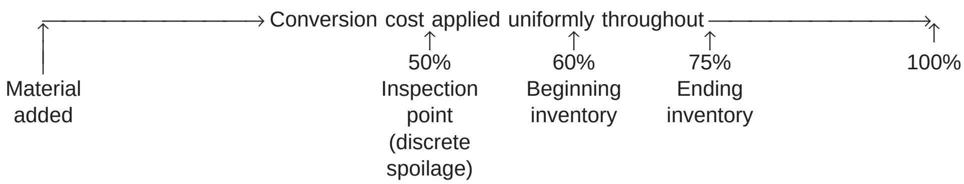
(Concluded)

COST ASSIGNMENT

Transferred:		
Beginning inventory	$16,620	
Cost to complete: Conversion (800 × $1.28)	1,024	
Total cost of beginning inventory	$17,644	
Started and completed (11,200 × $8.13)	91,056	
Normal spoilage (1,300 × $8.13)*	10,569	
Total cost of gallons transferred (13,200 × $9.04)**		$119,269
Ending inventory:		
Material (2,500 × $6.85)	$17,125	
Conversion (1,875 × $1.28)	2,400	19,525
Total costs accounted for (off due to rounding)		$138,794

*All spoilage cost is assigned to the units transferred.
**For convenience and clerical efficiency, modified FIFO is used. Otherwise, spoilage would have to be allocated to beginning WIP and units started and completed. The $9.04 figure is also computed as the sum of the $8.24 cost [($17,644 + $91,056) ÷ 13,200] per good EUP plus another $0.80. This $0.80 is the spoilage cost ($10,569) divided by the 13,200 good units transferred.

is so minimal that Impervious cannot justify the need for an end-of-process inspection. The flow diagram for this situation follows:



Using the same data as in the two previous situations, Exhibit 7–4 provides the cost per gallon and cost assignment for this situation. Spoiled gallons are extended in the EUP schedule at the inspection point degree of completion (100 percent for material and 50 percent for conversion) and affect the cost per gallon. As in Situation 2, the resulting cost per gallon reflects what the cost would have been had all the gallons produced been good output. Total cost of the spoiled goods is calculated by multiplying the component cost per gallon by the EUP for each cost component. Total spoilage cost is then prorated based on the EUP for each cost component between gallons transferred and gallons in ending inventory.

Situation 4—Abnormal Shrinkage (Continuous or Discrete); Some Normal Shrinkage (Continuous)

The final example of Impervious Inc. assumes that normal spoilage cannot exceed 5 percent of the gallons placed into production. Additionally, as in Situation 1, the unit reduction is assumed to occur from shrinkage. The quality control inspection point is at the end of processing. Because 15,000 gallons were started in April, the maximum allowable normal shrinkage is 750 gallons (15,000 × 5%). Because the total reduction in units in April was 1,300 gallons, 550 gallons are considered abnormal shrinkage. Exhibit 7–5 presents the cost of production report for Situation 4.

The approach presented for Situation 4 has one inequity. A portion of the normal shrinkage is automatically allocated to abnormal shrinkage because the calculation of EUP allows for the "disappearance" of the normal shrinkage. Cost per gallon is then computed based on the equivalent units of production. This approach

EXHIBIT 7–4

Cost of Production Report for Month Ended April 30, 2000 (FIFO method) (Normal discrete spoilage)

PRODUCTION DATA

	Whole Units	EQUIVALENT UNITS Material	Conversion
Beginning inventory (100%; 60%)	2,000		
Gallons started	15,000		
Gallons to account for	17,000		
Beginning inventory completed (0%; 40%)	2,000	0	800
Gallons started and completed	11,200	11,200	11,200
Total gallons completed	13,200		
Ending inventory (100%; 75%)	2,500	2,500	1,875
Normal spoilage (100%; 50%)	1,300	1,300	650
Gallons accounted for	17,000	15,000	14,525

COST DATA

	Total	Material	Conversion
Beginning inventory costs	$ 16,620		
Current costs	122,175	$102,750	$19,425
Total costs	$138,795		
Divided by EUP		15,000	14,525
Cost per FIFO EUP	$8.19	$6.85	$1.34

COST ASSIGNMENT

Transferred:		
From beginning inventory	$ 16,620	
Cost to complete: Conversion (800 × $1.34)	1,072	
Total cost of beginning inventory	$ 17,692	
Started and completed (11,200 × $8.19)	91,728	
Cost prior to proration of spoilage	$109,420	
Normal spoilage*	8,051	
Total cost of gallons transferred		$117,471
Ending inventory:		
Material (2,500 × $6.85)	$ 17,125	
Conversion (1,875 × $1.34)	2,513	
Cost prior to proration of spoilage	$ 19,638	
Normal spoilage*	1,725	
Total cost of ending inventory		21,363
Total costs accounted for (off due to rounding)		$138,834

*Proration of normal spoilage is as follows:

	Material EUP	Material %	Conversion EUP	Conversion %
Gallons started and completed**	11,200	82	11,200	86
Ending work in process	2,500	18	1,875	14
	13,700	100	13,075	100

Given the above relative EUP percentages, proration of spoilage costs is

Material (1,300 × $6.85)	$8,905
Conversion (650 × $1.34)	871
Cost of normal spoilage to be prorated	$9,776

**The gallons in beginning WIP were not included in this calculation because beginning WIP was 100% complete as to material and 60% complete as to conversion. Thus, this inventory was beyond the inspection point (50%) and no spoilage cost should be assigned to it.

(continued)

EXHIBIT 7–4

(Concluded)

	Material	Conversion	Total
Gallons started and completed:			
0.82 × $8,905	$7,302		
0.86 × $ 871		$749	$8,051
Ending work in process:			
0.18 × $8,905	1,603		
0.14 × $ 871		122	1,725
Total allocations	$8,905	$871	$9,776

EXHIBIT 7–5

Cost of Production Report for Month Ended April 30, 2000 (FIFO method) (Abnormal shrinkage; normal continuous shrinkage)

PRODUCTION DATA		EQUIVALENT UNITS	
	Whole Units	Material	Conversion
Beginning inventory (100%; 60%)	2,000		
Gallons started	15,000		
Gallons to account for	17,000		
Beginning inventory completed (0%; 40%)	2,000	0	800
Gallons started and completed	11,200	11,200	11,200
Total gallons completed	13,200		
Ending inventory (100%; 75%)	2,500	2,500	1,875
Normal shrinkage	750		
Abnormal shrinkage (100%; 100%)	550	550	550
Gallons accounted for	17,000	14,250	14,425

COST DATA	Total	Material	Conversion
Beginning inventory costs	$ 16,620		
Current costs	122,175	$102,750	$19,425
Total costs	$138,795		
Divided by EUP		14,250	14,425
Cost per FIFO EUP	$8.56	$7.21	$1.35

COST ASSIGNMENT		
Transferred:		
From beginning inventory	$16,620	
Cost to complete: Conversion (800 × $1.35)	1,080	
Total cost of beginning inventory	$17,700	
Started and completed (11,200 × $8.56)	95,872	
Total cost of gallons transferred		$113,572
Ending inventory:		
Material (2,500 × $7.21)	$18,025	
Conversion (1,875 × $1.35)	2,531	20,556
Abnormal loss (550 × $8.56)		4,708
Total costs accounted for (off due to rounding)		$138,836

is justified on the basis of expediency as long as the amount of the allocation of normal shrinkage to abnormal shrinkage is not considered significant.

Situation 4 is used to illustrate the journal entries necessary to account for shrinkage or spoilage. These entries are as follows:

Work in Process Inventory	122,175	
Raw Material Inventory		102,750
Wages Payable (and/or other appropriate accounts)		19,425
To record current period costs.		
Finished Goods Inventory	113,572	
Work in Process Inventory		113,572
To record cost transferred from the department.		
Loss from Abnormal Spoilage	4,708	
Work in Process Inventory		4,708
To remove cost of abnormal spoilage from Work in Process Inventory.		

The accounts debited and credited in the first journal entry would be the same for Situations 1, 2, and 3. The dollar amount of the second entry would change for each of Situations 1, 2, and 3 to reflect the appropriate "cost transferred" figure shown in the respective cost of production report. The third journal entry given is made only when abnormal defects/spoilage occurs.

All illustrations to this point have used FIFO process costing. If the weighted average method were used, the difference would appear (as discussed in Chapter 6) only in the treatment of beginning inventory and its related costs. Lost units would be handled as illustrated in each exhibit shown for Situations 1 through 4. Exhibit 7–6 illustrates the weighted average method for the data used in Exhibit 7–5.

EXHIBIT 7–6

Cost of Production Report for Month Ended April 30, 2000 (Weighted average method) (Abnormal shrinkage; normal continuous shrinkage)

PRODUCTION DATA		EQUIVALENT UNITS	
	Whole Units	Material	Conversion
Beginning inventory (100%; 60%)	2,000	2,000	1,200
Gallons started	15,000		
Gallons to account for	17,000		
Beginning inventory completed (0%; 40%)	2,000	0	800
Gallons started and completed	11,200	11,200	11,200
Total gallons completed	13,200		
Ending inventory (100%; 75%)	2,500	2,500	1,875
Normal spoilage	750		
Abnormal spoilage (100%; 100%)	550	550	550
Gallons accounted for	17,000	16,250	15,625

COST DATA	Total	Material	Conversion
Beginning inventory costs	$ 16,620	$ 15,000	$ 1,620
Current costs	122,175	102,750	19,425
Total costs	$138,795	$117,750	$21,045
Divided by EUP		16,250	15,625
Cost per FIFO EUP	$8.60	$7.25	$1.35

COST ASSIGNMENT		
Transferred (13,200 × $8.60)		$113,520
Ending inventory:		
Material (2,500 × $7.25)	$18,125	
Conversion (1,875 × $1.35)	2,531	20,656
Abnormal loss (550 × $8.60)		4,730
Total costs accounted for (off due to rounding)		$138,906

A summary of the treatment of various types of lost units in a process costing system is shown in Exhibit 7–7.

EXHIBIT 7–7

Summary of Handling Lost Units in a Process Costing System

	NORMAL	ABNORMAL
CONTINUOUS	Do not include equivalent lost units in EUP schedule. Units effectively "disappear"; unit costs of good production are increased.	Must include equivalent lost units in EUP schedule. Assign cost to lost units and charge as loss of period.
DISCRETE	Must include equivalent lost units in EUP schedule. Assign cost to lost units. Determine point of ending work in process: a. if before inspection point, assign cost of lost units only to units transferred. b. if after inspection point, prorate cost of spoiled units between units transferred and units in ending inventory.	Must include equivalent lost units in EUP schedule. Assign cost to lost units and charge as loss of period.

DEFECTIVE UNITS

5

How are rework costs of defective units treated?

The preceding examples have all presumed that the lost units were valueless. However, some goods that do not meet quality specifications are merely defective rather than spoiled, and thus have value. Such units are either reworked to meet product specifications or sold as irregulars. Rework cost is a product or period cost depending on whether the rework is considered to be normal or abnormal.

If the rework is normal and actual costing is used, the rework cost is added to the current period's work in process costs for good units and assigned to all units completed. In companies using predetermined overhead application rates, normal rework costs should be estimated and included as part of the estimated factory overhead cost used in computing the overhead application rates. In this way, the overhead application rate will be large enough to cover rework costs. When actual rework costs are incurred, they are assigned to the Manufacturing Overhead account.

If rework is abnormal, the costs should be accumulated and assigned to a loss account. The units are included in the EUP schedule for the period and only actual production (not rework) costs will be considered in determining unit cost.[3]

Reworked units may be irregular and have to be sold at less than the normal selling price. The production costs of irregular items should be transferred to a special inventory account and not commingled with the production costs of good units. When the net realizable value (selling price minus cost to rework and sell) is less than total cost, the difference is referred to as a deficiency. If the number of defective units is normal, the deficiency should be treated as part of the production cost of good units. If some proportion of the defective units is considered an abnormal loss, that proportion of the deficiency should be written off as a period cost.

[3] If the company is using a standard costing system, then standard costs will be considered when determining unit costs.

Accounting for defective units is illustrated by the July 2000 manufacturing data of Impervious Inc. During July, the company produced 17,900 good gallons and 100 defective gallons of paint. The 100 gallons were considered defective because the traditional neutral color of the product was, instead, slightly yellow. Total production costs other than rework were $160,200. The 100 defective gallons can be reworked at a total cost of $140 (or $1.40 per gallon) by mixing the defective gallons with a chemical lightening additive. The cost of the additive itself is only $0.07 per gallon, so all rework costs are assumed to be related to direct labor. The chemical additive is also gaseous and will cause no increase in the number of gallons of the paint. Entries for defective units are shown in Exhibit 7–8. This exhibit uses this information to show a variety of circumstances involving defective goods.

EXHIBIT 7–8

Entries for Defective Units

Good production: 17,900 gallons
Defects: 100 gallons
Cost of production other than rework: $160,200
Cost of rework: $140 or $1.40 per gallon

1. Rework is normal; actual costing is used; reworked gallons can be sold at normal selling price

Work in Process Inventory	140	
Wages Payable		140

Cost per acceptable gallon = $8.91 ($160,340 ÷ 18,000)

2. Rework is normal; predetermined OH rate is used (rework estimated); reworked gallons can be sold at normal selling price

Manufacturing Overhead	140	
Wages Payable		140

Cost per acceptable gallon = $8.90 ($160,200 ÷ 18,000)

3. Rework is abnormal; reworked gallons can be sold at normal selling price

Loss from Defects	140	
Wages Payable		140

Cost per acceptable gallon = $8.90 ($160,200 ÷ 18,000)

4. Reworked gallons are irregular; can only be sold for $7; actual costing is used

Normal production cost ($8.90 × 100)	$ 890
Cost of rework	140
Total cost of defective units	$1,030
Total sales value of defective units (100 × $7)	700
Total deficiency	$ 330

If defects are normal:

Inventory—Defects	700	
Work in Process Inventory	140	
Wages Payable		140
Work in Process Inventory		700

The deficiency ($330) remains with the good units; cost per acceptable gallon is $8.92: [($160,200 + $140 − $700) ÷ 17,900]

If defects are abnormal:

Inventory—Defects	700	
Loss from Defects	330	
Wages Payable		140
Work in Process Inventory		890

The deficiency is assigned as a period loss; cost per acceptable gallon is $8.90: [($160,200 − $890) ÷ 17,900]

DEFECTS/SPOILAGE IN JOB ORDER COSTING

6

How are losses treated in a job order costing system?

The previous examples are related to spoilage issues in a process costing environment. In a job order situation, the accounting treatment of spoilage depends on two issues: (1) Is spoilage generally incurred for most jobs or is it specifically identified with a particular job? (2) Is the spoilage normal or abnormal?

Generally Anticipated on All Jobs

net cost of normal spoilage

If normal spoilage is anticipated on all jobs, the predetermined overhead application rate should include an amount for the **net cost of normal spoilage**, which is equal to the cost of spoiled work less the estimated disposal value of that work. This approach assumes that spoilage is naturally inherent and unavoidable in the production of good products, and its estimated cost should be proportionately assigned among the good products produced.

Assume that Impervious produces a special paint for manufacturers. Each production run is considered a separate job because each manufacturer indicates the particular paint specifications it requires. Regardless of the job, there is always some shrinkage because of the mixing process. In computing the predetermined overhead rate related to the custom paints, the following estimates are made:

Overhead costs other than spoilage		$121,500
Estimated spoilage unit cost	$10,300	
Sales of improperly mixed paints to foreign distributors	(4,300)	6,000
Total estimated overhead		$127,500
Estimated gallons of production during the year		÷ 150,000
Predetermined overhead rate per gallon		$0.85

During the year, Impervious Inc. accepted a job (#38) from General Electric to manufacture 500 gallons of paint. Direct material cost for this job was $4,660, direct labor cost totaled $640, and applied overhead was $425 ($0.85 × 500 gallons), giving a total cost for the job of $5,725. Impervious Inc. put 500 gallons of paint into production. Five gallons (or 1 percent) of the paint became defective during the production process when a worker accidentally added a thickening agent meant for another job into a container of the paint. The actual cost of the defective mixture was $57.25 (0.01 × $5,725) and it can be sold for $22. The entry below is made to account for the actual defect cost:

Disposal Value of Defective Work	22.00	
Manufacturing Overhead	35.25	
Work in Process Inventory—Job #38		57.25
To record disposal value of defective work incurred on Job #38 for General Electric.		

The estimated cost of spoilage was originally included in determining the predetermined overhead rate. Therefore, as actual defects or spoilages occur, the disposal value of the nonstandard work is included in an inventory account (if salable), and the net cost of the normal nonstandard work is charged to the Manufacturing Overhead account as is any other actual overhead cost.

Specifically Identified with a Particular Job

If defects or spoilages are not generally anticipated, but are occasionally experienced on specific jobs *because of job-related characteristics*, the estimated cost should *not* be included in setting the predetermined overhead application rate. Because the cost of defects/spoilage attaches to the job, the disposal value of such goods reduces the cost of the job that created those goods. If no disposal value exists for the defective/spoiled goods, that cost remains with the job that caused the defects/spoilage.

Assume that Impervious did not typically experience spoilage in its production process. The company's predetermined overhead would have been calculated as $0.81 per gallon ($121,500 ÷ 150,000). Thus, the total cost for the General Electric job would have been $5,705 [$4,660 + $640 + ($0.81 × 500)]. Five gallons of the batch were thickened somewhat greater than normal at the request of General Electric. After checking the stirability of the special paint, General Electric rejected the five gallons and changed the formula slightly. The five gallons could be sold for $22; this amount would reduce the cost of the General Electric job as shown in the following entry:

Disposal Value of Defective Work	22	
Work in Process Inventory—Job #38		22
To record disposal value of defective work incurred on Job #38 for General Electric.		

The production cost of any new mixture will be assigned a new job number.

Abnormal Spoilage

The cost of abnormal losses (net of any disposal value) should be written off as a period cost. The following entry assumes that Impervious normally anticipates some lost units on its custom orders and that the estimated cost of those units was included in the development of a predetermined overhead application rate. Assume that on Job #135, the cost of defective units was $198, but that $45 of disposal value was associated with those units. Of the remaining $153 of cost, $120 was related to normal defects and $33 was related to abnormal defects.

Disposal Value of Defective Work	45	
Manufacturing Overhead	120	
Loss from Abnormal Spoilage	33	
Work in Process Inventory—Job #135		198
To record reassignment of cost of defective and spoiled work on Job #135.		

The first debit represents the defective goods' disposal value; the debit to Manufacturing Overhead is for the net cost of normal spoilage. The debit to Loss from Abnormal Spoilage is for the portion of the net cost of spoilage that was not anticipated in setting the predetermined application rate.

ACCRETION

7

How does accretion of units affect the EUP schedule and costs per unit?

accretion

Accretion refers to an increase in units or volume because of the addition of material or to factors (such as heat) that are inherent in the production process.[4] For example, adding soybean derivative to beef in preparing packages of hamburger causes the pounds of product to increase just as including pasta increases the volume of a casserole.

If materials are added in a single department, the number of equivalent units computed for that department compensates for this increase from the beginning to the end of processing. When accretion occurs in successor departments in a multi-department process, the number of units transferred into the department and the related cost per unit must be adjusted. For instance, assume that one paint made by Impervious Inc. requires processing in two departments. Department 2 adds a compound to increase the scratch-resistant properties of the mixture produced in Department 1. The gallons of compound added increase the total gallons of mixture that were transferred out of Department 1 and decrease the transferred-in cost per unit.

The production of this heavy-duty paint is used to illustrate the accounting for accretion of units in a successor department. Department 1 mixes the primary paint

[4] Not all additions of material in successor departments cause an increase in units. Adding bindings to books in a second department does not increase the number of books printed and transferred from the prior department. When the material added in a successor department does not increase the number of units, it is accounted for as shown in Chapter 6.

ingredients in large vats and sends the mixture to Department 2, which adds the scratch-resistant compound and remixes the paint. The paint is poured into 50-gallon containers that are shipped to buyers. Spoilage occurs in Department 2 when too much scratch-resistant compound is added to the paint mixture. The spoilage is detected when the mixture is transferred from the vats to the containers. Spoilage is never containerized. Spoilage is considered normal as long as it does not exceed 1 percent of the gallons transferred into Department 2 from Department 1.

December production information for Department 2 is given below. For this product, assume that Impervious Inc. uses weighted average process costing. The units in beginning inventory were 100 percent complete as to the compound, 0 percent complete as to the container, and 25 percent complete as to conversion costs. Ending inventory is 100 percent complete as to the compound, 0 percent complete as to the container, and 70 percent complete as to conversion.

Gallons in beginning inventory	1,000
Gallons transferred in	21,000
Gallons of compound added	5,000
Gallons in ending inventory	1,200
Units completed (50-gallon containers)	512

Note that the measure for completed production is containers rather than gallons. Because each container represents 50 gallons, the actual gallons completed are 25,600 (50 × 512). To handle this change in measuring units, either the incoming gallons must be reported as containers or the completed containers must be reported as gallons. The cost of production report for December (Exhibit 7–9) is prepared using gallons as the measurement unit, and assumed cost information is supplied in the exhibit.

Several items need to be noted about Exhibit 7–9. First, the number of spoiled gallons was determined by subtracting the total gallons completed plus the gallons in ending inventory from the total gallons for which the department was responsible. Because spoilage was less than 1 percent of the gallons transferred into Department 2, it was all considered normal. Second, the $197,100 cost transferred from Department 1 was related to 22,000 gallons of mixture: the gallons in beginning inventory plus those transferred during the period. Thus, the original cost of each gallon was approximately $8.96 ($197,100 ÷ 22,000). With the addition of the compound in Department 2, the transferred-in cost per gallon declined to $7.30.

EXHIBIT 7–9

Department 2 Cost of Production Report for the Month Ended December 31, 2000 (Weighted average method)

PRODUCTION DATA		EQUIVALENT UNITS			
	Whole Units	Transferred-In	Compound	Container	Conversion
Beginning inventory (100%; 100%; 0%; 25%)	1,000	1,000	1,000	0	250
Transferred-in (gals.)	21,000				
Compound added (gals.)	5,000				
Gallons to account for	27,000				
BI completed	1,000	0	0	1,000	750
Started and completed	24,600	24,600	24,600	24,600	24,600
Total gallons completed	25,600				
Ending inventory (100%; 100%; 0%; 7%)	1,200	1,200	1,200	0	840
Normal spoilage	200	200	200	0	200
Gallons accounted for	27,000	27,000	27,000	25,600	26,640

(continued)

COST DATA		EQUIVALENT UNITS			
	Total	Transferred-In	Compound	Container	Conversion
BI costs	$ 8,415	$ 7,385	$ 840	$ 0	$ 190
Current costs	331,455	189,715	22,110	99,840	19,790
Total costs	$339,870	$197,100	$22,950	$99,840	$19,980
Divided by EUP		27,000	27,000	25,600	26,640
Cost per EUP	$12.80	$7.30	$0.85	$3.90	$0.75

COST ASSIGNMENT		
Transferred:		
Cost of good units (25,600 × $12.80)	$327,680	
Cost of spoilage:		
Transferred-in (200 × $7.30)	1,460	
Compound (200 × $0.85)	170	
Conversion (200 × $0.75)	150	
Total cost transferred		$329,460
Ending inventory:		
Transferred-in (1,200 × $7.30)	$ 8,760	
Compound (1,200 × $0.85)	1,020	
Conversion (840 × $0.75)	630	10,410
Total costs accounted for		$339,870

EXHIBIT 7–9

(Concluded)

Third, spoilage is assignable only to the completed units because the ending inventory has not yet reached the discrete point of inspection (transference to containers). Finally, the average cost of each 50-gallon container completed is approximately $643.48 ($329,460 ÷ 512).

CONTROLLING QUALITY TO MINIMIZE LOST UNITS

8

What is the cost of quality products?

Up to this point, the chapter has focused on how to account for lost units in the production process. The fact is, if there were no lost units (from shrinkage, defects, or spoilage), there would be no need to account for them. The control aspect in quality control requires knowledge of three questions in addition to the six questions posed earlier in the chapter:

1. What do the lost units actually cost?
2. Why do the lost units occur?
3. How can the lost units be controlled?

Many companies find it difficult—if not impossible—to answer the question of what lost units (or the lack of quality) cost. A direct cause of part of this difficulty is the use of the traditional method of assigning the cost of normal losses to the good units produced. By excluding lost units from the extensions in the equivalent units schedule, the cost of those units is effectively "buried" and hidden in magnitude from managers. In a job order costing environment, if the cost of lost units is included in calculating the predetermined overhead rate, that cost is also being hidden and ignored. In service organizations, the cost of "lost units" may be even more difficult to determine because those lost units are, from a customer viewpoint, poor service. After such service, the customer simply may not do business with the organization again. Such an opportunity cost is not processed by the accounting system. Thus, in all instances, a potentially significant dollar amount is unavailable for investigation as to its planning, controlling, and decision-making ramifications.

As to the second question, managers may be able to pinpoint the reasons for lost units or poor service but may also have two perspectives of those reasons that instinctively allow for a lack of control. First, managers may believe that the cause creates only a "minimal" quantity of lost units; such a mind-set creates the predisposition for an "accepted quality level" with some tolerance for error. These error tolerances are built into the system and become justifications for problems. Production is "graded on a curve" that allows for a less-than-perfect result.

Incorporating error tolerances into the production/performance system and combining such tolerances with the method of neglect results in managers not being provided with the information necessary to determine how much spoilage cost is incurred by the company. Therefore, although believing that the quantity and cost of lost units are "minimal," the managers do not have historical or even estimated accounting amounts on which to base such a conclusion. By becoming aware of the costs, managers could make more informed decisions about whether to ignore the costs or try to correct their causes.

In other instances, managers may believe that the quantity of lost units is uncontrollable. In some cases, this belief is accurate. For example, the shrinkage of coffee beans during roasting is virtually uncontrollable as is the sticking of small amounts of candy bar coating to candy molds during processing. The frequency of problems such as these is not large. Process analysis has proven that the cost of attempting to correct this production defect would be significantly greater than the savings resulting from the correction. But in most production situations and almost every service situation, the cause of lost units or poor service is controllable. Managers should determine the cause of the problem and institute corrective action.

Defects and spoiled units were originally controlled through a process of inspecting goods or, in the case of service organizations, through surveying customers. These control methods are known as appraisal techniques. Now companies are deciding that if quality is built into the process, fewer inspections or surveys will be needed because defects/spoilage and poor service will be minimized. This involves prevention techniques. The goal, then, is prevention of defects or errors rather than output inspection or observation. Preventing defects and errors requires that managers discover the root cause of the defect or error. The accompanying News Note discusses root cause analysis.

As discussed in Chapter 8, companies implementing quality programs to minimize defects/spoilage or poor service often employ a tool called statistical process control (SPC) to analyze their processes to determine whether any situations are "out of control." SPC uses graphs and/or control charts to understand and reduce fluctuations in processes until they are under control.

SPC requires that those persons or machines involved in problem areas select a relevant measure of performance and track that performance measurement over time. The resulting control chart provides information on the circumstances existing when a problem arises. Analyzing this chart in relation to the benchmark or standard and to the amount of variation expected in a stable (controlled) process provides process control information that lets the company improve its performance.

SPC allows the individuals involved with the process to become the quality control monitoring points and helps to eliminate the need for separate quality inspections. Thus, the "accepted quality level" can be raised, and the defects can be significantly reduced. Consider what can happen to a firm that aspires to deliver parts with zero defects when reading the News Note on page 282 about the experiences of Fraen Corp.

http://www.fraen.com
http://www.aimcoinc.com

QUALITY NEWS NOTE

Analyzing Root Causes

How much time, effort, and money do companies lose dealing with problems that continually resurface and disrupt the organization? This is known as the "price of nonconformance"—the failure to identify a problem's root cause, fix the process, measure results, and follow up.

Estimates of the price of nonconformance are as much as 25 to 40% of operating costs. However, by focusing on the process—not the people—organizations can correct the underlying causes of problems so they don't recur.

By preventing the recurrence of errors in service delivery or manufacturing processes, significant improvements in both productivity and quality are assured. By eliminating nonconformance in the system through zero defects and anticipating and preventing errors prior to process implementation, significant cost savings may be realized to positively impact the organization's profit margin. With an understanding of the environment necessary to create quality, organizations will identify solutions to costly, recurring problems.

The implementation of a system process improvement model . . . utilizing step-by-step root cause analysis will create an effective continuous quality improvement culture in an organization. Utilizing a step-by-step root cause analysis process, organizations can improve product quality, improve service quality, reduce operating costs, and impact operating profits positively.

The "root cause" is the reason for a nonconformance within a process. It is the underlying cause of a problem, not just the apparent cause. It is a focus on the process, not the people.

The root cause is a factor that, when changed or eliminated, will eliminate the nonconformance and prevent the problem. It is about designing prevention solutions into how work is done. Prevention solutions are not about reworking, redesigning, modifying, or fixing things; they are not about correction. Prevention solutions are about determining why the rework was required, why we must redesign the product, and why we must fix the item. It is about determining how to keep the problem from ever occurring again. It is about designing prevention into the process.

Root cause analysis is a formal, structured, disciplined approach to problem solving. Many root cause analysis processes have been developed to approach problem solving: some have three steps, some four, some six, or as many as 12 steps in the process.

Simply, root cause analysis is a systematic process of defining the problem, gathering and prioritizing data about the nonconformance, analyzing solutions to the problem, and evaluating the benefits versus the cost-effectiveness of all available prevention options.

SOURCE: Charles C. Handley, "Quality Improvement through Root Cause Analysis," *Hospital Material Management Quarterly* (May 2000), pp. 74–75. Originally published and copyrighted by APICS–The Educational Society for Resource Management, © 1999 APICS International Conference Proceedings.

The process of developing, implementing, and interpreting an SPC system requires a firm grasp on statistics and is well beyond the scope of this text. However, cost and management accountants must recognize the usefulness of such a tool in determining why problems occur. This knowledge allows cost and management accountants to better track the costs flowing into the problem areas, estimate the opportunity costs associated with the problems, and perform a more informed cost-benefit analysis about problem correction.

In conclusion, the important managerial concern regarding spoilage is in controlling it rather than accounting for spoilage costs. Quality control programs can be implemented to develop ideas on product redesign for quality, determine where quality control problems exist, decide how to measure the costs associated with those problems, and assess how to correct the problems. If quality is defined in an organization as zero lost units (excepting those caused by inherent shrinkage), all defects/spoilage will be accounted for as an abnormal cost of production or service. Such accounting would mean that defect/spoilage costs would no longer be hidden from managerial eyes through the use of the method of neglect discussed earlier in the chapter.

NEWS NOTE QUALITY

Keeping an "Eye" on Things

When a small company is trying to make the leap to big contender, it needs all the help it can get. Fraen Corp. of Reading, MA, was intent on becoming a major supplier of precision machined parts, and had finally found its opportunity: a multinational corporation needed a massive quantity of electronic component fasteners. Fraen, which employed around 175 workers, felt it could deliver, but wanted to make itself stand out from its larger competitors. It offered the corporation zero defects per million parts, 100% inspection.

The corporation accepted. Before this contract, Fraen produced around 500,000 parts/week. With the new job, it would be shipping out 8 million parts. Higher volume meant that quality control would also have to be upgraded, especially since Fraen offered zero defects. The upgrade would be considerable: "We had no system—just people," explained David Cohen, Fraen's former quality manager, and now director of business development. "[The workers] would go to the machines and check parts on a regular basis, at a predetermined frequency, and record the information by hand on a piece of paper."

Fraen began investigating different inspection technologies, and also accepting bids with solutions and quotes. The company was approached by Advanced Inspection and Measurement (AIM, Niantic, CT), a manufacturer of contact and noncontact inspection systems. AIM proposed two video inspection systems, each incorporating a parts feeder and a set of three cameras that visually inspect parts and send the information to an adjoining PC, which then sends the data to a mother computer that determines part quality. Fraen decided to purchase two systems from AIM and set the systems up in a cleanroom to begin inspecting the constant flow of parts.

There was little or no training involved in learning how to operate the systems. Fraen hired two workers to run the machines, both of whom had no previous training in running video inspection systems. Both workers readily learned the operation. Cohen said that if the company had not purchased the vision inspection systems, it would have had to hire an additional 20 people to help with inspection. In addition, the systems provided real-time data, allowing Fraen to fine-tune its process.

The company, however, did not anticipate how statistically overwhelming 100% inspection could be. "Transitioning the factory from sampling parts and measuring via statistical sampling, to 100% inspection and having all of the data from every piece from every machine every day was a challenge, because you had an enormous amount of data all of a sudden," Cohen said. "We fill up a CD-ROM each week with data, so figuring out what to do with all of that and how to manage it was pretty difficult." Fraen eventually hired a full-time analyst to manage the information.

The investment was well worth the effort, according to Cohen. The two systems enabled Fraen to provide its customers with zero defects. As a result, the company purchased six more systems, as well as additional production machinery and a new facility. "We're actively pursuing high-volume jobs because of those systems, and word has gotten out about our quality," Cohen concluded. "We established ourselves as a player against people who otherwise would have buried us."

SOURCE: Samantha Hoover, "Visual Inspection System Keeps Up with Production Leap," *Quality* (March 1999), pp. 46ff.

REVISITING General Electric Company

http://www.ge.com

In the initial stages of Six Sigma, GE's efforts consisted of training more than 100,000 people in its science and methodology and focusing thousands of "projects" on improving efficiency and reducing variances from its internal operations—from industrial factories to financial services back rooms.

From there, the company's operating system steered the initiative into design engineering to prepare future generations of customer-interactive processes of the financial services businesses. Medical Systems used it to open up a commanding technology lead in several diagnostic platforms and has achieved dramatic sales increases and customer satisfaction improvements. By 1999, GE had undertaken 20,000 quality initiatives resulting in an average 80 percent error reduction.

Every GE product business and financial service activity is using Six Sigma in its product design and fulfillment processes. A growing number of Six Sigma projects are now under way for customers, many on customer premises.

In 1996, GE's CEO, Jack Welch, rang the opening bell at the New York stock exchange celebrating the 100th anniversary of the Dow Jones Index. His presence was significant, because GE is the only company on the original index that is still on the list. GE became the first company in the world to exceed $200 billion market capitalization, and in 1998 it crossed the $100 billion mark in revenue.

Given the above, is it surprising that GE was named "America's Most Admired Corporation" in 2000 for the third year in a row?

SOURCES: General Electric Company Web site, http://www.ge.com (June 2000); Staff, "GE: Lighting the Way," *Machine Design* (September 23, 1999), pp. 123–129; Geoffrey Colvin, "America's Most Admired Companies," *Fortune* (February 21, 2000), pp. 108, 110.

CHAPTER SUMMARY

This chapter covers the accounting treatment for shrinkage, defective and spoiled units, and accretion of units in a process costing system. Management typically specifies a certain level of shrinkage/defects/spoilage that will be tolerated as normal if a loss of units is commonly anticipated. If lost units exceed that expectation, the excess is considered an abnormal loss. Normal losses are product costs, and abnormal losses are period costs.

To account for the cost of lost units, the location of the loss within the process must be known in addition to knowing whether the quantity of lost units is normal or abnormal. If the loss point is continuous, the period's good production absorbs the cost of the lost units. This treatment is handled in the cost of production report by not extending the lost units to the equivalent units columns. If the loss point is discrete, lost units are included in the EUP schedule at their unit equivalency at the quality control point. If ending inventory has reached the inspection point, the cost of the lost units is allocated both to units transferred from the department and units in ending inventory. If ending inventory has not yet reached the quality control inspection point, the lost unit cost attaches only to the units transferred.

In a job order costing system, the cost of anticipated defects/spoilage is estimated and included in setting the predetermined overhead rate. This approach allows expected cost of lost units to be assigned to all jobs. When lost units occur, any disposal value of those units is carried in a separate inventory account; the net cost of defects/spoilage is debited to Manufacturing Overhead. If lost units do not generally occur in a job order system, any normal defects/spoilage associated with a specific job is carried as part of that job's cost; the disposal value of such units reduces the cost of the specific job.

Treatment of the rework cost for defective units depends on whether the rework is normal or abnormal. If rework is normal, the cost is considered to be a product cost and either (1) increases actual costs in the cost schedule or (2) is considered in setting an overhead application rate and charged to overhead when incurred. If rework is abnormal, the cost is assigned to the period as a loss.

Adding material to partially completed units may increase the number of units. If the material addition occurs in a successor department, a new transferred-in cost per unit must be calculated using the increased number of units. If units of measure change between the start and end of production, a consistent measuring unit must be used in the cost of production report to properly reflect production of the period.

Accounting for spoiled and defective units is essential when total quality does not exist. The traditional methods of accounting for spoilage often "bury" the cost of poor quality by spreading that cost over good output. Managers should attempt to compute the costs of spoiled or defective units and search for ways to improve product quality, reduce product cost, and increase the company's competitive market position.

KEY TERMS

abnormal loss (p. 263)
accepted quality level (AQL) (p. 261)
accretion (p. 277)
continuous loss (p. 264)
defective unit (p. 263)
discrete loss (p. 264)
economically reworked (p. 263)
method of neglect (p. 265)
net cost of normal spoilage (p. 276)
normal loss (p. 263)
shrinkage (p. 262)
spoiled unit (p. 263)

SOLUTION STRATEGIES

Lost units are *always* shown with other whole units under "Units accounted for" in the cost of production report.

Continuous Normal Loss

1. Lost units are *not* extended to EUP schedule.
2. All good production (both fully and partially completed) absorbs the cost of the lost units through higher per-unit costs.

Continuous Abnormal Loss

1. All units are appropriately extended to EUP schedule.
2. Cost of lost units is assigned as a period loss.

Discrete Normal Loss

1. Normal loss is appropriately extended to EUP schedule.
2. Determine whether ending inventory has passed an inspection point.
   a. If no, cost of lost units is assigned only to the good production that was transferred.
   b. If yes, cost of lost units is prorated between units in ending WIP Inventory and units transferred out based on (1) (weighted average) total costs contained in each category prior to proration, or (2) (FIFO) current costs contained in each category prior to proration.

Discrete Abnormal Loss

1. All units are appropriately extended to EUP schedule.
2. Cost of lost units is assigned as a period loss.

Normal Rework

1. *(Actual cost system)* Add rework costs to original material, labor, and overhead costs and spread over all production.
2. *(Normal and standard cost systems)* Include cost of rework in estimated overhead when determining standard application rate. Assign actual rework costs to Manufacturing Overhead.

Abnormal Rework

Accumulate rework costs separately and assign as a period loss.

Accretion in Successor Departments

An increase in units requires that the per-unit transferred-in cost be reduced in the successor department based on the new, larger number of units.

DEMONSTRATION PROBLEM

Maura Nobile & Company incurs spoilage continuously throughout the manufacturing process. All materials are added at the beginning of the process, and the inspection point is at the end of the production process. April 2000 operating statistics are as follows:

Pounds			
Beginning inventory (75% complete)			2,000
Started in April			10,000
Completed and transferred			9,500
Ending inventory (70% complete)			1,000
Normal spoilage			900
Abnormal spoilage			?
Costs			
Beginning inventory			
Material	$117,780		
Conversion	47,748	$ 165,528	
Current period			
Materials	$546,000		
Conversion	325,500	871,500	
Total costs		$1,037,028	

Required:

a. Prepare a cost of production report using the weighted average method.
b. Prepare a cost of production report using the FIFO method.
c. Using the information from part (b), prepare the journal entry to recognize the abnormal loss from spoilage.

Solution to Demonstration Problem

a.

MAURA NOBILE & COMPANY
Cost of Production Report
(Continuous spoilage—normal & abnormal; weighted average method)
For the Month Ended April 30, 2000

PRODUCTION DATA	Whole Units	EQUIVALENT UNITS Material	Conversion
Beginning inventory (100%; 75%)	2,000	2,000	1,500
+ Pounds started	10,000		
= Pounds to account for	12,000		
Beginning inventory completed (0%; 25%)	2,000	0	500
+ Pounds started and completed	7,500	7,500	7,500
= Total pounds completed	9,500		
+ Ending inventory (100%; 70%)	1,000	1,000	700
+ Normal spoilage	900		
+ Abnormal spoilage (100%; 100%)	600	600	600
= Pounds accounted for	12,000	11,100	10,800

(continued)

COST DATA

		Total	Material	Conversion
Beginning inventory costs		$ 165,528	$117,780	$ 47,748
Current costs		871,500	546,000	325,500
Total costs		$1,037,028	$663,780	$373,248
Divided by EUP			11,100	10,800
Cost per WA EUP		$94.36	$59.80	$34.56

COST ASSIGNMENT

Transferred (9,500 × $94.36)		$ 896,420
Ending inventory:		
Material (1,000 × $59.80)	$59,800	
Conversion (700 × $34.56)	24,192	83,992
Abnormal loss (600 × $94.36)		56,616
Total costs accounted for		$1,037,028

b.

MAURA NOBILE & COMPANY
Cost of Production Report
(Continuous spoilage—normal & abnormal; FIFO method)
For the Month Ended June 30, 2000

PRODUCTION DATA

	Whole Units	EQUIVALENT UNITS Material	EQUIVALENT UNITS Conversion
Beginning inventory (100%; 75%)	2,000	2,000	1,500
+ Pounds started	10,000		
= Pounds to account for	12,000		
Beginning inventory completed (0%; 25%)	2,000	0	500
+ Pounds started and completed	7,500	7,500	7,500
= Total pounds completed	9,500		
+ Ending inventory (100%; 70%)	1,000	1,000	700
+ Normal spoilage	900		
+ Abnormal spoilage (100%; 100%)	600	600	600
= Pounds accounted for	12,000	11,100	9,300

COST DATA

	Total	Material	Conversion
Beginning inventory costs	$ 165,528		
Current costs	871,500	$546,000	$325,500
Total costs	$1,037,028		
Divided by EUP		9,100	9,300
Cost per FIFO EUP	$95	$60	$35

COST ASSIGNMENT

Transferred:		
From beginning inventory	$165,528	
Cost to complete: Conversion (500 × $35)	17,500	
Total cost of beginning inventory	$183,028	
Started and completed (7,500 × $95)	712,500	
Total cost of pounds transferred		$ 895,528
Ending inventory:		
Material (1,000 × $60)	$ 60,000	
Conversion (700 × $35)	24,500	84,500
Abnormal loss (600 × $95)		57,000
Total costs accounted for		$1,037,028

c.	Loss from Abnormal Spoilage	57,000	
	Work in Process Inventory		57,000
	To remove cost of abnormal spoilage from Work in Process Inventory account.		

QUESTIONS

1. Explain the meaning of an accepted quality level and discuss it in relation to a zero tolerance for defects or errors approach.
2. Differentiate among shrinkage, spoilage, and defects.
3. What are some reasons a company would set a "tolerated" loss level? How might such a level be set?
4. List five examples (similar to the blackened redfish illustration in the text) in which a unit would be considered (a) defective and (b) spoiled.
5. What is the difference between a normal and an abnormal loss?
6. Why would abnormal losses be more likely to be preventable than some types of normal losses?
7. How does a continuous loss differ from a discrete loss?
8. When does a discrete loss actually occur? When is it assumed to occur for accounting purposes? Why are these not necessarily at the same point?
9. Why is the cost of an abnormal loss considered a period cost? How is its cost removed from Work in Process Inventory?
10. What is meant by the term *method of neglect*? When is this method used?
11. How does use of the method of neglect affect the cost of good production in a period?
12. In a job order costing system, spoilage may be incurred in general for all jobs or it may be related to a specific job. What differences do these circumstances make in the treatment of spoilage?
13. In a production process, what is accretion? How does it affect the cost of the units transferred in from a predecessor department?
14. The Mixing Department of Leeward Company transferred 100,000 gallons of material to the Baking Department during July. The cost per gallon transferred out shown on Mixing's cost of production report was $2.50. On Baking's cost of production report for the same period, the cost per gallon for material transferred in was $2.00. Why might the cost have changed?
15. How are costs of reworking defective units treated if the defects are considered normal? Abnormal?
16. A company has an AQL for defects of 5 percent of units started during the period. Current period loss was 3 percent. Why should management attempt to measure the cost of this loss rather than simply include it as part of the cost of good production?
17. How do statistical process control techniques contribute to the control of spoilage costs?
18. Search the Internet for a company that has a zero tolerance for defects policy and report on the results of the company's efforts to reach its goals.

EXERCISES

19. *(Terminology)* Match the following lettered terms on the left with the appropriate numbered definition on the right.

a. Abnormal loss
b. Acceptable quality level
c. Accretion
d. Defective unit
e. Economically reworked
f. Method of neglect
g. Normal loss
h. Spoiled unit

1. Allowing the production of spoiled units to increase the cost of good production
2. Decreases the transferred-in cost per unit
3. Results from having defective production greater than the AQL
4. A unit that is discarded on inspection
5. A unit that can be reworked
6. An expected decline in units in the production process
7. Additional processing that results in net incremental revenue
8. Maximum limit below which the frequency of defects in a process is accepted as normal

20. *(Cost-benefit analysis)* Alfred Carlson, plant manager at WEBOXALL Company, is investigating spoilage created by a machine that prints packing boxes for TVs and other large, fragile items. At the beginning of each production run, 50 boxes are misprinted either because of miscoloration or misalignment. These boxes must be destroyed. The variable production cost per box is $6.00. The machine averages 200 setups for production runs each year.

A regulator is available that will correct the problem. Alfred is trying to decide whether to purchase the regulator.

a. At what cost for the regulator would the benefit of acquisition not exceed the cost? What other factors should Alfred consider in addition to the purchase price of the regulator?
b. If each setup produces an average of 500 boxes, what is the increased cost per good box that is caused by the spoiled units?
c. WEBOXALL Company runs 12 batches per year for Springtime Corporation, which makes very specialized equipment in limited quantities. Thus, each batch contains only 20 boxes. If WEBOXALL Company is passing its spoilage cost on to customers based on batch costs, might Springtime Corporation be willing to buy the regulator for WEBOXALL Company if the regulator costs $3,300? Justify your answer.
d. Why are the cost-per-box answers in parts (b) and (c) so different?

21. *(Normal vs. abnormal spoilage; WA)* Jacksonville Plastics uses a weighted average process costing system for its production process in which all material is added at the beginning of production. Company management has specified that the normal loss cannot exceed 7 percent of the units started in a period. All losses are caused by shrinkage. March processing information follows:

Beginning inventory (10% complete—conversion)	8,000 units
Started during March	60,000 units
Completed during March	53,000 units
Ending inventory (60% complete—conversion)	10,000 units

a. How many total units are there to account for?
b. How many units should be treated as normal loss?
c. How many units should be treated as abnormal loss?
d. What are the equivalent units of production for direct material? For conversion?

22. *(EUP computations; normal and abnormal loss)* The Atlanta Division of Southeastern Paint produces environmental paints in processes in which spoilage takes place on a continual basis. Management considers normal spoilage to be 0.5 percent or less of gallons of material placed into production. The following operating statistics are available for June 2000 for the paint BMZ:

Beginning inventory (20% complete as to material; 30% complete as to conversion)	8,000 gallons
Started during June	180,000 gallons
Ending inventory (60% complete as to material; 70% complete as to conversion)	4,000 gallons
Spoiled	1,400 gallons

a. How many gallons were transferred out?
b. How much normal spoilage occurred?
c. How much abnormal spoilage occurred?
d. What are the FIFO equivalent units of production for materials? For conversion costs?
e. How are costs associated with the normal spoilage handled?
f. How are costs associated with the abnormal spoilage handled?

23. *(EUP computation; normal and abnormal loss; FIFO)* Arkansas Foods manufactures corn meal in a continuous, mass-production process. Corn is added at the beginning of the process. Losses are few and occur only when foreign materials are found in the corn meal. Inspection occurs at the 95 percent completion point as to conversion.

During May, a machine malfunctioned and dumped salt into 18,000 pounds of corn meal. This abnormal loss occurred when conversion was 70 percent complete on those pounds of product. The error was immediately noticed, and those pounds of corn meal were pulled from the production process. An additional 1,000 pounds of meal were detected as unsuitable at the inspection point. These lost units were considered well within reasonable limits. May production data are shown below:

Beginning work in process (85% complete)	50,000 pounds
Started during the month	425,000 pounds
Ending work in process (25% complete)	10,000 pounds

a. Determine the number of equivalent units for direct material and for conversion assuming a FIFO cost flow.
b. If the costs per equivalent unit are $2.50 and $4.50 for direct material and conversion, respectively, what is the cost of ending inventory?
c. What is the cost of abnormal loss? How is this cost treated in May?

24. *(EUP computation; normal and abnormal loss; cost per EUP; FIFO)* CandleSticks uses a FIFO process costing system to account for its candle production process. Wax occasionally forms imperfectly in molds and, thus, spoilage is viewed as continuous. The accepted quality level is good output of 92 percent of the pounds of wax placed in production. All wax is entered at the beginning of the process. March 2001 data follow:

Beginning inventory (30% complete as to conversion)	9,000 pounds
Started during month	30,000 pounds
Transferred	31,500 pounds
(315,000 candles; 10 wax candles are obtained from a pound of wax)	
Ending inventory (20% complete as to conversion)	5,400 pounds
Loss	? pounds

The following costs are associated with March production:

Beginning inventory:		
Material	$3,600	
Conversion	2,700	$ 6,300
Current period:		
Material	$9,207	
Conversion	8,964	18,171
Total costs		$24,471

a. Prepare the production data segment of CandleSticks' cost of production report for March 2001.
b. Compute the cost per equivalent unit for each cost component.
c. Assign March costs to the appropriate units.

25. *(Cost assignment; WA)* CushionRide manufactures automobile springs. Its production equipment is fairly old, and one bad unit is typically produced for every 20 good units. The bad units cannot be reworked and must be discarded. Spoilage is determined at an end-of-process inspection point. CushionRide uses a weighted average process costing system and adds all material at the beginning of the process. The following data have been gathered from the accounting records for January 2001:

Beginning inventory (60% complete as to conversion)	4,000 units
Units started	20,000 units
Ending inventory (30% complete as to conversion)	3,000 units
Good units completed	20,000 units

	Material	Conversion	Total
Beginning inventory	$ 12,492	$ 9,927	$ 22,419
Current period	112,548	63,000	175,548
Total costs	$125,040	$72,927	$197,967

a. Prepare an EUP schedule.
b. Determine the cost of the normal spoilage and allocate that cost to the appropriate inventory.

26. *(Normal discrete spoilage; WA)* The Potato Division of Global Foods Company processes potatoes. In the process, raw potatoes are sequentially cleaned, skinned, cooked, and canned. Spoilage amounting to less than 12 percent of the total pounds of potatoes that are introduced to the cleaning operation is considered normal (in this case, normal spoilage is to include the weight of the potato peels). Inspection occurs when the products are 50 percent complete. Information that follows pertains to operations in the Potato Division for January 2000:

Beginning WIP inventory (30% complete)	500,000 pounds
Started	13,500,000 pounds
Transferred	11,400,000 pounds
Ending WIP inventory (40% complete)	750,000 pounds

a. Compute the amount of spoilage in January. How much of the spoilage was normal?
b. Compute the equivalent units of production assuming the weighted average method is used.
c. Prepare a memo explaining why you might expect some (1) accretion in the canning operation and (2) some shrinkage other than the weight of the peels in one or more of the operations.

27. *(Rework)* Auto Luster Inc. manufactures two-gallon tubs of car polish for body shops. The company uses an actual cost, process costing system. All material is added at the beginning of production; labor and overhead are incurred evenly through the process. Defective units are identified through inspection at the end of the production process. The following information is available for August 2001:

Beginning inventory (30% complete as to conversion)	750 units
Started during month	17,250 units
Completed during month	15,000 units
Defective units (100% complete as to conversion)	1,800 units
Ending inventory (70% complete as to conversion)	1,200 units

Actual August production costs (including those for beginning inventory) were $126,000 for direct material and $40,572 for conversion. In addition, the rework cost to bring the 1,800 units up to specifications was $3,150 for material and $1,323 for conversion.

a. Determine the equivalent units of production using the weighted average method.

b. Assume that the rework is normal. Determine the cost per good unit for direct material and conversion.

c. Assume that the rework is normal. How would the rework cost be handled in a normal (rather than actual) costing system?

d. Assume that the rework is abnormal. Determine the cost per good unit for direct material and conversion. How is the rework cost recorded for financial statement purposes?

28. *(Controlling losses)* For each of the following types of production losses or poor service, indicate whether prevention (P) or appraisal (A) techniques would provide the most effective control mechanism. Explain why you made your choice.

a. Putting pages in upside down in a book.

b. Bolting the wrong parts together.

c. Shrinkage from cooking.

d. Breaking glasses when they are being boxed.

e. Paying an account payable twice.

f. Bringing the wrong meal to a restaurant customer.

PROBLEMS

29. *(Shrinkage; WA)* Department 1 of Super Patties cooks ground beef for hamburger patties. The patties are then transferred to Department 2 where they are placed on buns, boxed, and frozen. The accepted level of shrinkage in Department 1 is 10 percent of the pounds started. Super Patties uses a weighted average process costing system and has the following production and cost data for Department 1 for May 2001:

Beginning inventory (80% complete as to conversion)	1,000 pounds
Started	125,000 pounds
Transferred to Department 2 (550,000 patties)	110,000 pounds
Ending inventory (30% complete as to conversion)	3,000 pounds
Beginning inventory cost of ground beef	$ 1,020
May cost of ground beef	$106,710
Beginning inventory conversion cost	$ 195
May conversion cost	$ 27,630

a. What is the total shrinkage (in pounds)?

b. How much of the shrinkage is classified as normal? How is it treated for accounting purposes?

c. How much of the shrinkage is classified as abnormal? How is it treated for accounting purposes? *(continued)*

d. What is the total cost of the patties transferred to Department 2? Cost of ending inventory? Cost of abnormal spoilage?

e. How might Super Patties reduce its shrinkage loss? How, if at all, would your solution(s) affect costs?

30. *(Discrete spoilage; WA)* Angelique Inc. makes stuffed angels in a mass-production process. Cloth and stuffing are added at the beginning of the production process; the angels are packaged in sky-blue boxes at the end of production. Conversion costs for the highly automated process are incurred evenly throughout processing. The angels are inspected at the 95 percent completion point prior to being boxed. Defective units of more than 1 percent of the units started is considered abnormal.

The company uses a weighted average process costing system. June 2001 production and cost data for Angelique Inc. follow:

Beginning inventory (40% complete as to conversion)	5,000
Started	70,000
Ending inventory (70% complete as to conversion)	6,000
Total defective units	400
Beginning inventory cloth and stuffing cost	$ 21,900
Beginning inventory conversion cost	$ 7,680
June cloth and stuffing cost	$315,600
June box cost	$ 75,460
June conversion cost	$270,404

a. How many units were completed in June?

b. How many of the defective units are considered a normal loss? An abnormal loss?

c. What is the per-unit cost of the completed units? What would the per-unit cost of the completed units have been if the 400 units had been good units at their same stages of completion at the end of the period?

d. What is the total cost of ending inventory?

31. *(Normal and abnormal discrete spoilage; WA)* Brendan Tools manufactures one of its products in a two-department process. A separate Work in Process account is maintained for each department, and Brendan Tools uses a weighted average process costing system. The first department is Molding; the second is Grinding. At the end of production in Grinding, a quality inspection is made and then packaging is added. Overhead is applied in the Grinding Department on a machine-hour basis. Production and cost data for the Grinding Department for August 2000 follow:

Production Data

Beginning inventory (complete: labor, 30%; overhead, 40%)	2,000 units
Transferred-in from Molding	49,800 units
Normal spoilage (discrete—found at the end of processing during quality control)	650 units
Abnormal spoilage (found at end of processing during quality control)	350 units
Ending inventory (complete: labor, 40%; overhead, 65%)	1,800 units
Transferred to finished goods	? units

Cost Data

Beginning inventory:		
Transferred-in	$ 6,050	
Material (label and package)	0	
Direct labor	325	
Overhead	750	$ 7,125
Current period:		
Transferred-in	$149,350	
Material (label and package)	11,760	
Direct labor	23,767	
Overhead	50,932	235,809
Total cost to account for		$242,934

a. Prepare a cost of production report for the Grinding Department for August.
b. Prepare the journal entry to dispose of the cost of abnormal spoilage.

32. *(Normal and abnormal spoilage; WA)* Big Stone Furniture produces breakfast tables in a two-department process: Cutting/Assembly and Lamination. Varnish is added in the Lamination Department when the goods are 60 percent complete as to overhead. Spoiled units are found on inspection at the end of production. Spoilage is considered discrete.

PRODUCTION DATA FOR APRIL 2000

Beginning inventory (80% complete as to labor, 70% complete as to overhead)	2,000 units
Transferred in during month	14,900 units
Ending inventory (40% complete as to labor, 20% complete as to overhead)	3,000 units
Normal spoilage (found at final quality inspection)	200 units
Abnormal spoilage (found at 30% completion as to labor and 15% as to overhead; the sanding machine was misaligned and scarred the tables)	400 units
The remaining units were transferred to finished goods.	

COST DATA FOR APRIL 2000

Beginning Work in Process Inventory:		
Prior department costs	$ 15,020	
Varnish	1,900	
Direct labor	4,388	
Overhead	11,044	$ 32,352
Current period costs:		
Prior department costs	$137,080	
Varnish	14,030	
Direct labor	46,000	
Overhead	113,564	310,674
Total costs to account for		$343,026

Determine the proper disposition of the April costs for the Lamination Department using the weighted average method; include journal entries.

33. *(Normal and abnormal discrete spoilage; FIFO)* Use the Big Stone Furniture information from Problem 32. Determine the proper disposition of the April costs of the Lamination Department using the FIFO method; include journal entries.

34. *(Normal and abnormal discrete spoilage; FIFO)* Reagan Company produces hinges. Completed hinges are inspected at the end of production. Any spoilage in excess of 2 percent of the completed units is considered abnormal. Material is added at the start of production. Labor and overhead are incurred evenly throughout production.

Reagan's May 2001 production and cost data follow:

Beginning inventory (50% complete)	5,600
Units started	74,400
Good units completed	70,000
Ending inventory (1/3 complete)	7,500

	Material	Conversion	Total
Beginning inventory	$ 6,400	$ 1,232	$ 7,632
Current period	74,400	31,768	106,168
Total	$80,800	$33,000	$113,800

Calculate the equivalent units schedule, prepare a FIFO cost of production report, and assign all costs.

35. *(Normal and abnormal discrete spoilage; WA)* Use the Reagan Company data as given in Problem 34. Prepare a May 2001 cost of production report using the weighted average method.

36. *(Cost assignment)* Data below summarize operations for GreenerGrass Company for March 2001. The company makes five-gallon containers of weed killer/fertilizer. All material is added at the beginning of the process.

COSTS

	Material	Conversion	Total
Beginning inventory	$ 30,000	$ 3,600	$ 33,600
Current period	885,120	335,088	1,220,208
Total costs	$915,120	$338,688	$1,253,808

UNITS

Beginning inventory (30% complete-conversion)	6,000 units
Started	180,000 units
Completed	152,000 units
Ending inventory (70% complete-conversion)	20,000 units
Normal spoilage	4,800 units

Spoilage is detected at inspection when the units are 60 percent complete.

a. Prepare an EUP schedule using the weighted average method.

b. Determine the cost of goods transferred out, ending inventory, and abnormal spoilage.

37. *(Cost assignment)* Patio Products employs a weighted average process costing system for its products. One product passes through three departments (Molding, Assembly, and Finishing) during production. The following activity took place in the Finishing Department during May 2001:

Units in beginning inventory	4,200
Units transferred in from Assembly	42,000
Units spoiled	2,100
Good units transferred out	33,600

The equivalent units and the costs per equivalent unit of production for each cost factor are as follows:

Cost of prior departments	$5.00
Raw material	1.00
Conversion	3.00
Total cost per EUP	$9.00

Raw material is added at the beginning of processing in Finishing without changing the number of units being processed. Work in Process Inventory was 70 percent complete as to conversion on May 1 and 40 percent complete as to conversion on May 31. All spoilage was discovered at final inspection. Of the total units spoiled, 1,680 were within normal limits.

a. Calculate the equivalent units of production.

b. Determine the cost of units transferred out of Finishing.

c. Determine the cost of ending Work in Process Inventory.

d. The portion of the total transferred-in cost associated with beginning Work in Process Inventory amounted to $18,900. What is the current period cost that was transferred in from Assembly to Finishing?

e. Determine the cost associated with abnormal spoilage for the month. How would this amount be accounted for? *(CMA adapted)*

38. *(Comprehensive; weighted average)* Harper Company produces brooms. Department 1 winds and cuts straw into broom heads and transfers these to Department 2 where the broom head is bound and attached to a handle. Straw is added at the beginning of the first process, and the handle is added at the end of the second process.

Normal losses in Department 1 should not exceed 5 percent of the units started; losses are determined at an inspection point at the end of the production process. The AQL in Department 2 is 10 percent of the broom heads transferred in; losses are found at an inspection point located 70 percent of the way through the production process.

The following production and cost data are available for October 2001.

PRODUCTION RECORD (IN UNITS)

	Dept. 1	Dept. 2
Beginning inventory	6,000	3,000
Started or transferred in	150,000	?
Ending inventory	18,000	15,000
Spoiled units	9,000	6,000
Transferred out	?	111,000

COST RECORD

	Dept. 1	Dept. 2
Beginning inventory:		
Preceding department	n/a	$ 6,690
Material	$ 3,000	0
Conversion	2,334	504
Current period:		
Preceding department	n/a	230,910*
Material	36,000	740
Conversion	208,962	52,920

*This is not the amount derived from your calculations. Use this amount so that you do not carry forward any possible cost errors from Department 1.

The beginning and ending inventory units in Department 1 are, respectively, 10 percent and 60 percent complete as to conversion. In Department 2, the beginning and ending units are, respectively, 40 percent and 80 percent complete as to conversion.

Using the weighted average method, create a cost of production report for each department for October 2001.

39. *(Comprehensive; FIFO)* Use the information for Harper Company from Problem 38 to prepare a FIFO cost of production report for each department for October 2001.

40. *(Comprehensive; WA and FIFO)* Andaman Company mines salt in southern Florida. Approximately 30 percent of the mined salt is processed into table salt. Andaman Company uses a process costing system for the table salt operation. Processing takes place in two departments. Department 1 uses FIFO costing, and Department 2 uses weighted average. The cost of the processed salt transferred from Department 1 to Department 2 is averaged over all the units transferred.

Salt is introduced into the process in Department 1. Spoilage occurs continuously through the department and normal spoilage should not exceed 10 percent of the units started; a unit is 50 pounds of salt.

Department 2 packages the salt at the 75 percent completion point; this material does not increase the number of units processed. A quality control inspection takes place when the goods are 80 percent complete. Spoilage should not exceed 5 percent of the units transferred in from Department 1.

The following production and cost data are applicable to Andaman Company's table salt operations for July 2001:

DEPARTMENT 1 PRODUCTION DATA

Beginning inventory (65% complete)	5,000
Units started	125,000
Units completed	110,000
Units in ending inventory (40% complete)	14,000

DEPARTMENT 1 COST DATA

Beginning inventory:		
Material	$ 7,750	
Conversion	11,500	$ 19,250
Current period:		
Material	$190,400	
Conversion	393,225	583,625
Total costs to account for		$ 602,875

DEPARTMENT 2 PRODUCTION DATA

Beginning inventory (90% complete)	40,000
Units transferred in	110,000
Units completed	120,000
Units in ending inventory (20% complete)	22,500

DEPARTMENT 2 COST DATA

Beginning inventory:		
Transferred-in	$204,000	
Material	120,000	
Conversion	21,600	$ 345,600
Current period:		
Transferred-in	$568,500*	
Material	268,875	
Conversion	55,395	892,770
Total costs to account for		$1,238,370

*This may not be the same amount determined for Department 1; ignore any difference and use this figure.

a. Compute the equivalent units of production in each department.

b. Determine the cost per equivalent unit in each department and compute the cost transferred out, cost in ending inventory, and cost of spoilage (if necessary).

41. *(Defective units and rework)* Hoffus Corporation produces plastic pipe and accounts for its production process using weighted average process costing. Material is added at the beginning of production. The company applies overhead to products using machine hours. Hoffus Corporation used the following information in setting its predetermined overhead rate for 2000:

Expected overhead other than rework	$425,000
Expected rework costs	37,500
Total expected overhead	$462,500
Expected machine hours for 2000	50,000

During 2000, the following production and cost data were accumulated:

Total good production completed	2,000,000 feet of pipe
Total defects	40,000 feet of pipe
Ending inventory (35% complete)	75,000 feet of pipe

Total (beginning inventory and current period) cost of direct material	$3,750,000
Total (beginning inventory and current period) cost of conversion	$5,650,000
Cost of reworking defects	$ 37,750

Hoffus Corporation sells pipe for $3.50 per foot.

a. Determine the overhead application rate for 2000.

b. Determine the cost per pipe-foot for production in 2000.

c. Assume that the rework is normal and those units can be sold for the regular selling price. How will Hoffus Corporation account for the $37,750 of rework cost?

d. Assume that the rework is normal, but the reworked pipe is irregular and can only be sold for $2.50 per foot. Prepare the journal entry to establish the inventory account for the reworked pipe. What is the total cost per unit for the good output completed?

e. Assume that 20 percent of the rework is abnormal and that all reworked output is irregular and can be sold for only $2.50 per foot. Prepare the journal entry to establish the inventory account for the reworked pipe. What is the total cost per foot for the good output completed during 2000?

42. *(Job order costing; rework)* Argonne Rigging manufactures pulley systems to customer specifications and uses a job order system. A recent order from Michaels Company was for 10,000 pulleys, and the job was assigned number BA468. The job cost sheet for #BA468 revealed the following:

WIP—JOB #BA468

Direct material	$20,400	
Direct labor	24,600	
Overhead	18,400	
Total	$63,400	

Final inspection of the 10,000 pulleys revealed that 230 of the pulleys were defective. In correcting the defects, an additional $950 of cost was incurred ($250 for direct material and $700 for direct labor). After the defects were cured, the pulleys were included with the other good units and shipped to the customer.

a. Assuming the rework costs are normal but specific to this job, show the journal entry to record incurrence of the rework costs.

b. Assuming the company has a predetermined overhead rate that includes normal rework costs, show the journal entry to record incurrence of the rework costs.

c. Assuming the rework costs are abnormal, show the journal entry to record incurrence of the rework costs.

CASE

43. *(Normal and abnormal spoilage; WA)* Grand Monde Company manufactures various lines of bicycles. Because of the high volume of each type of product, the company employs a process cost system using the weighted average method to determine unit costs. Bicycle parts are manufactured in the Molding Department and transferred to the Assembly Department where they are partially assembled. After assembly, the bicycle is sent to the Packing Department.

Cost-per-unit data for the 20-inch dirt bike has been completed through the Molding Department. Annual cost and production figures for the Assembly Department are presented at the top of the next page.

PRODUCTION DATA

Beginning inventory (100% complete as to transferred-in; 100% complete as to assembly material; 80% complete as to conversion)	3,000 units
Transferred in during the year (100% complete as to transferred-in)	45,000 units
Transferred to Packing	40,000 units
Ending inventory (100% complete as to transferred-in; 50% complete as to assembly material; 20% complete as to conversion)	4,000 units

COST DATA

	Transferred-In	Direct Material	Conversion
Beginning inventory	$ 82,200	$ 6,660	$ 11,930
Current period	1,237,800	96,840	236,590
Totals	$1,320,000	$103,500	$248,520

Damaged bicycles are identified on inspection when the assembly process is 70 percent complete; all assembly material has been added at this point of the process. The normal rejection rate for damaged bicycles is 5 percent of the bicycles reaching the inspection point. Any damaged bicycles above the 5 percent quota are considered to be abnormal. All damaged bikes are removed from the production process and destroyed.

a. Compute the number of damaged bikes that are considered to be
   1. a normal quantity of damaged bikes.
   2. an abnormal quantity of damaged bikes.

b. Compute the weighted average equivalent units of production for the year for
   1. bicycles transferred in from the Molding Department.
   2. bicycles produced with regard to assembly material.
   3. bicycles produced with regard to assembly conversion.

c. Compute the cost per equivalent unit for the fully assembled dirt bike.

d. Compute the amount of the total production cost of $1,672,020 that will be associated with the following items:
   1. Normal damaged units
   2. Abnormal damaged units
   3. Good units completed in the Assembly Department
   4. Ending Work in Process Inventory in the Assembly Department

e. Describe how the applicable dollar amounts for the following items would be presented in the financial statements:
   1. Normal damaged units
   2. Abnormal damaged units
   3. Completed units transferred to the Packing Department
   4. Ending Work in Process Inventory in the Assembly Department

f. Determine the cost to Grand Monde Company of normal spoilage. Discuss some potential reasons for spoilage to occur in this company. Which of these reasons would you consider important enough to correct and why? How might you attempt to correct these problems? *(CMA adapted)*

REALITY CHECK

44. AudioSpectrum produces complex printed circuits for stereo amplifiers. The circuits are sold primarily to major component manufacturers, and any production overruns are sold to small manufacturers at a substantial discount. The small manufacturer segment appears to be very profitable because the basic operating budget assigns all fixed expenses to production for the major manufacturers, the only predictable market.

A common product defect that occurs in production is a "drift," caused by failure to maintain precise heat levels during the production process. Rejects from the 100 percent testing program can be reworked to acceptable levels if the defect is drift. However, in a recent analysis of customer complaints, Andrew Hill, the cost accountant, and the quality control engineer have ascertained that normal rework does not bring the circuits up to standard. Sampling shows that about one-half of the reworked circuits fail after extended, high-volume amplifier operation. The incidence of failure in the reworked circuits is projected to be about 10 percent over one to five years of operation.

Unfortunately, there is no way to determine which reworked circuits will fail because testing does not detect this problem. The rework process could be changed to correct the problem, but the cost-benefit analysis for the suggested change in the rework process indicates that it is not practicable. AudioSpectrum's marketing analyst feels that this problem will have a significant impact on the company's reputation and customer satisfaction if it is not corrected. Consequently, the board of directors would interpret this problem as having serious negative implications for the company's profitability.

Hill has included the circuit failure and rework problem in his report for the upcoming quarterly meeting of the board of directors. Due to the potential adverse economic impact, Hill has followed a long-standing practice of highlighting this information.

After reviewing the reports to be presented, the plant manager and her staff were upset and indicated to the controller that he should control his people better. "We can't upset the board with this kind of material. Tell Hill to tone that down. Maybe we can get it by this meeting and have some time to work on it. People who buy those cheap systems and play them that loud shouldn't expect them to last forever."

The controller called Hill into his office and said, "Andrew, you'll have to bury this one. The probable failure of reworks can be referred to briefly in the oral presentation, but it should not be mentioned or highlighted in the advance material mailed to the board."

Hill feels strongly that the board will be misinformed on a potentially serious loss of income if he follows the controller's orders. Hill discussed the problem with the quality control engineer, who simply remarked, "That's your problem, Andrew."

a. Discuss the ethical considerations that Andrew Hill should recognize in deciding how to proceed in this matter.

b. Explain what ethical responsibilities should be accepted in this situation by
  1. The controller.
  2. The quality control engineer.
  3. The plant manager and her staff.

c. What should Andrew Hill do in this situation? Explain your answer.

(CMA adapted)

45. Every job has certain requirements, and quality is defined by meeting those requirements. In some cases, however, people make decisions to override requirements. In a team of three or four, choose four requirements for your class (or for a job held by one of you). Prepare a memo that would explain to your teacher (or your boss) the following:

a. The requirements you have chosen and why you think the teacher (boss) made those requirements.

b. The conditions under which your team would decide to override the requirements.

(continued)

c. Why you believe that overriding the requirements would be appropriate in the conditions you have specified.

d. The potential for problems that may arise by overriding the requirements.

46. Use library, Internet, or personal resources to find three companies that instituted workforce education programs and, thereby, reduced the number of lost units. Prepare a five- to seven-minute oral presentation about your companies' programs and their benefits.

47. All world-class models (TQM, JIT, ABM, and theory of constraints) advocate improving throughput as a way to improve quality and minimize defects. Prepare a report for the board of directors of a company for which you are the newly appointed controller explaining why increasing throughput is linked to quality improvements and reduction of defects.

48. In accounting for spoilage, consideration should be given to how well the approach chosen to measure spoilage supports management's efforts to improve quality. Prepare a memo explaining how selecting a method to measure and account for spoilage can either assist or hinder management's efforts to improve quality.

49. The following is an excerpt from the Web site of Zero Defects, an electronics manufacturing service provider:

http://www.zerodefect.com

At Zero Defects, we have never believed that perfection is too much for our clients to expect. For over 15 years, the world's leading electronics companies have relied on us to provide legendary service and manufacture faultless products. When we say faultless, we mean much more than you might think. To us perfection means:

- *Delivering 100% usable product on time, every time.*
- *Providing service that meets and exceeds every expectation.*
- *Manufacturing each component in the most cost-effective way possible.*
- *Meeting your exact specifications and customizing any part of our production line to do so.*
- *Keeping costs at a bare minimum through tight internal controls and volume buying power.*
- *Providing and standing by detailed quotations and schedules.*
- *Preventing environmental damage through safe manufacturing and recycling programs.*

[SOURCE: Staff, Zero Defects Web site, http://www.zerod.com/index.htm, (June 15, 2000).]

Write a report briefly discussing this excerpt. Compare and contrast the approach explained in the excerpt with the traditional notion of only undertaking an action for which there is an expected net benefit using cost-benefit analysis.

50. Find three companies on the Internet (other than GE, the company featured in this chapter) that are using Six Sigma. Briefly discuss the results they have experienced from using it.