assistance and consultation programs. OSHA's mission is to ensure safe and healthful workplaces in America.

2. www.nist.gov/welcome.html The National Institute of Standards (NIST) is a non-regulatory federal agency within the U.S. Commerce Department's Technology Administration. NIST develops and promotes measurement, standards, and technology.
3. www.ansi.org The American National Standards Institute (ANSI) is a private, nonprofit organization that administers and coordinates the U.S. voluntary standardization and conformity assessment system.
4. www.iso.ch The International Organization for Standardization (ISO) is a non-governmental organization. It is a network of the national standards institutes from 148 countries, with one member per country and a Central Secretariat in Geneva, Switzerland, that coordinates the system.
5. www.astm.org The ASTM International, formerly known as the American Society for Testing and Materials, is a not-for-profit organization that provides a global forum for the development and publication of voluntary consensus standards for materials, products, systems, and services.

Safety

1. www.nsc.org National Safety Council. Excellent library for workplace safety consultants and human resources managers offering resources, member information, services, and publications.
2. www.construction-institute.org Home page of the Construction Industry Institute, University of Texas at Austin. Source of construction management research relating to best practices.
3. www.osha.gov Occupational Safety and Health Administration site. Includes news, statistics, publications, regulations, standards, and reference resources.
4. www.ntsb.gov National Transportation Safety Board. This independent federal agency conducts investigations on significant transportation accidents, and offers synopses and public hearing overviews.
5. www.crmusa.com Contractors Risk Management. Explore details of this company offering manuals, customized plans, and training programs for construction industry safety and health guidelines.
6. www.agc.org Associated General Contractors of America. Deals with contracting and safety issues and construction laws.

CHAPTER 2

Fundamental Concepts of Equipment Economics

A correct and complete understanding of the costs that result from equipment ownership and operation provide companies a market advantage that leads to greater profits. Ownership cost is the cumulative result of those cash flows an owner experiences whether or not the machine is productively employed on a project. Operating cost is the sum of those expenses an owner experiences by working a machine on a project. The process of selecting a particular type of machine for use in constructing a project requires knowledge of the cost associated with operating the machine in the field. There are three basic methods for securing a particular machine to use on a project: (1) buy, (2) rent, or (3) lease.

IMPORTANT QUESTIONS

Equipment cost is often one of a contractor's largest expense categories, and it is a cost fraught with variables and questions. To be successful, equipment owners must carefully analyze and answer two separate cost questions about their machines:

1. How much does it cost to operate the machine on a project?
2. What is the optimum economic life and the optimum manner to secure a machine?

The first question is critical to bidding and operations planning. The only reason for purchasing equipment is to perform work that will generate a profit for the company. This question seeks to identify the expense associated with productive machine work, and is commonly referred to as ownership and operating (O&O) cost. O&O cost is expressed in dollars per machine operating hour (e.g., \$90/hr for a dozer) because it is used in calculating the cost per unit of machine production. If a dozer can push 300 cy per hour and it has a $90/hr O&O cost, production cost is $0.300/cy ($90/hr ÷ 300 cy/hr). The estimator/planner can use the cost per cubic yard figure directly on unit price work. On a lump-sum job, it will be necessary to multiply the cost/unit price by the estimated quantity to obtain the total amount that should be charged.

The second question seeks to identify the optimum point in time to replace a machine and the optimum way to secure a machine. This is important in that it will affect O&O cost and can lower production expense, enabling a contractor to achieve a better pricing position. The process of answering this question is known as replacement analysis. A complete replacement analysis must also investigate the cost of renting or leasing a machine.

The economic analyses that answer these two cost questions require the input of many expense and operational factors. These input factors will be discussed first and a development of the analysis procedures follows.

EQUIPMENT RECORDS

Data on both machine utilization and costs are the keys to making rational equipment decisions, but the collection of individual pieces of data is only the first step. The data must be assembled and presented in usable formats. Many contractors recognize this need and strive to collect and maintain accurate equipment records for evaluating machine performance, establishing operating cost, analyzing replacement questions, and managing projects. Surveys of industrywide practices, however, indicate that such efforts are not universal.

Realizing the advantages to be gained therefrom, owners are directing more attention to accurate record keeping. Advances in computer technology have reduced the effort required to implement record systems. Computer companies offer record-keeping packages specifically designed for contractors. In many cases, the task is simply the retrieval of equipment cost data from existing accounting files.

Automation introduces the ability to handle more data economically and in shorter time frames, but the basic information required to make rational decisions is still the critical item. A commonly used technique in equipment costing and record keeping is the standard rate approach. Under such a system, jobs are charged a standard machine utilization rate for every hour the equipment is employed. Machine expenses are charged either directly to the piece of equipment or to separate equipment cost accounts. This method is sometimes referred to as an internal or company rental system. Such a system usually presents a fairly accurate representation of investment consumption and it properly assigns machines expenses. In the case of a company replacing machines each year and continuing in operation, this system enables a check at the end of each year on estimate rental rates as the internally generated rent should equal the expenses absorbed.

The first piece of information necessary for rational equipment analysis is not an expense but a record of the machine's use. One of the implicit assumptions of a replacement analysis is that there is a continuing need for a

machine's production capability. Therefore, before beginning a replacement analysis, the disposal–replacement question must be resolved. Is this machine really necessary? A projection of the ratio between total equipment capacity and utilized capacity provides a quick guide for the dispose–replace question.

The level of detail for reporting equipment use varies. Both independent service vendors and equipment companies (DeereTrax offered by John Deere and Product Link offered by Caterpillar being two examples) offer data collection devices that provide accurate real-time information about machine use. These devices are installed in the machine and transmit data via the most cost-effective wireless network (satellite or cellular networks). As a minimum, data should be collected on a daily basis to record whether a machine worked or was idle. A more sophisticated system will seek to identify use on an hourly basis, accounting for actual production time and categorizing idle time by classifications such as standby, down weather, and down repair. The input for either type of system is easily incorporated into regular personnel timekeeping reports, with machine time and operator time being reported together.

Most of the information required for ownership and operating or replacement analyses is available in the company's accounting records. All owners keep records on a machine's initial purchase expense and final realized salvage value as part of the accounting data required for tax filings. Maintenance expenses can be tracked from mechanics' time sheets, purchase orders for parts, or from shop work orders. Service logs provide information concerning consumption of consumables. Fuel amounts can be recorded at fuel points or with automated systems. Fuel amounts should be cross-checked against the total amount purchased. When detailed and correct reporting procedures are maintained, the accuracy of equipment costs analyses is greatly enhanced.

THE RENT PAID FOR THE USE OF MONEY

What is commonly referred to as the time value of money is the difference—rent—that must be paid if one borrows some money for use today and returns the money at some future date. Many take this charge for granted, as the proliferation of credit cards testifies. This rent or added charge is termed *interest*. It is the profit and risk that the lender applies to the base amount of money that is borrowed. Interest, usually expressed as a percentage of the amount borrowed (owed), becomes due and payable at the close of each billing time period. It is typically stated as a yearly rate. As an example, if $1,000 is borrowed at 8% interest, then $1,000 × 0.08, or $80, in interest plus the original $1,000 is owed after 1 year (yr). Therefore, the borrower would have to repay $1,080 at the end of a 1-yr time period. If this new total amount is not repaid at the end of the 1-yr period, the interest for the second year would be calculated based on the new total amount, $1,080, and thus the interest is *compounded*. Then, after a 2-yr period, the amount owed would be $1,080 + ($1,080 × 0.08), or $1,166.40. If the company's credit is good and it has borrowed the $1,000 from a bank, the banker normally does not care whether repayment is made after 1 yr at $1,080 or after 2 yr at $1,166.40. To the bank the three amounts, $1,000, $1,080, and $1,166.40, are equivalent. In other words, $1,000 today is equivalent to $1,080 1 yr in the future, which is also equivalent to $1,166.40 2 yr in the future. The three amounts are obviously not equal; they are *equivalent. Note that the concept of equivalence involves time and a specific rate of interest.* The three amounts are equivalent only for the case of an interest rate of 8%, and then only at the specified points in time. Equivalence means that one sum or series differs from another only by the accrued, accumulated interest at rate i for n periods of time.

Note that in the example the principal amount was multiplied by an interest rate to obtain the amount of interest due. To generalize this concept, the following symbols are used:

P = a present single amount of money
F = a future single amount of money, after n periods of time
i = the rate of interest per period of time (usually 1 yr)
n = the number of time periods

Different situations involving an interest rate and time are presented next, and the appropriate analytical formulas are developed.

Equation for Single Payments

To calculate the future value F of a single payment P after n periods at an interest rate i, these formulations are used:

At the end of the first period, $n = 1$: $F_1 = P + Pi$
At the end of the second period, $n = 2$: $F_2 = P + Pi + (P + Pi)i = P(1 + i)^2$
At the end of the nth period: $F = P(1 + i)^n$

Or the future single amount of a present single amount is

$$F = P(1 + i)^n \qquad [2.1]$$

Note that F is related to P by a factor that depends only on i and n. This factor is termed the *single payment compound amount factor (SPCAF)*; it makes *F equivalent to P*.

If a future amount F is given, the present amount P can be calculated by transposing the equation to

$$P = \frac{F}{(1 + i)^n} \qquad [2.2]$$

The factor $1/(1 + i)^n$ is known as the *present worth compound amount factor (PWCAF)*.

EXAMPLE 2.1

A constructor wishes to borrow $12,000 to finance a project. The interest rate is 5% per year. If the borrowed amount and the interest are paid back after 3 yr, what will be the total amount of the repayment?

To solve, use Eq. [2.1]

$$F = \$12{,}000\,(1 + 0.05)^3 = \$12{,}000\,(1.157625)$$
$$= \$13{,}891.50$$

The amount of interest is $1,891.50

EXAMPLE 2.2

A constructor wants to set aside enough money today in an interest-bearing account to have $100,000 5 yr from now for the purchase of a replacement piece of equipment. If the company can receive 8% per year on its investment, how much should be set aside now to accrue the $100,000 5 yr from now?

To solve, use Eq. [2.2]

$$P = \frac{\$100{,}000}{(1 + 0.08)^5} = \frac{\$100{,}000}{(1.469328)}$$
$$= \$68{,}058.32$$

In Examples 2.1 and 2.2 single payments now and in the future were equated. Four parameters were involved: P, F, i, and n. *Given any three parameters, the fourth can easily be calculated.*

Formulas for a Uniform Series of Payments

Often payments or receipts occur at regular intervals, and such uniform values can be handled by use of additional formulas. First, let us define another symbol:

A = uniform *end-of-period* payments or receipts continuing for a duration of n periods

If this uniform amount A is invested at the end of each period for n periods at a rate of interest i per period, then the total equivalent amount F at the end of the n periods will be

$$F = A[(1 + i)^{n-1} + (1 + i)^{n-2} + \cdots + (1 + i) + 1]$$

By multiplying both sides of the equation by $(1 + i)$ we obtain

$$F(1 + i) = A[(1 + i)^n + (1 + i)^{n-1} + (1 + i)^{n-2} + \cdots + (1 + i)]$$

Now by subtracting the original equation from both sides of the new equation, we obtain

$$Fi = A(1 + i)^n - 1$$

which can be rearranged to

$$F = A\left[\frac{(1 + i)^n - 1}{i}\right] \quad [2.3]$$

The relationship $[(1 + i)^n - 1]/i$ is known as the *uniform series, compound amount factor (USCAF).*

The relationship can be rearranged to yield

$$A = F\left[\frac{i}{(1 + i)^n - 1}\right] \quad [2.4]$$

The relationship $i/[(1 + i)^n - 1]$ is known as the *uniform series sinking fund factor (USSFF)* because it determines the uniform end-of-period investment A that must be made to provide an amount F at the end of n periods.

To determine the equivalent uniform period series required to replace a present value of P, simply substitute Eq. [2.1] for F into Eq. [2.4] and rearrange. The resulting equation is

$$P = A\left[\frac{(1 + i)^n - 1}{i(1 + i)^n}\right] \quad [2.5]$$

This relationship is known as the *uniform series present worth factor (USPWF).*

By inverting Eq. [2.5] the equivalent uniform series end-of-period value A can be obtained from a present value P. The equation is

$$A = P\left[\frac{i(1 + i)^n}{(1 + i)^n - 1}\right] \quad [2.6]$$

This relationship is known as the *uniform series capital recovery factor (USCRF).*

As an aid to understanding the six preceding equivalence relationships, appropriate cash flow diagrams can be drawn. *Cash flow diagrams* are drawings where the horizontal line represents time and the vertical arrows represent cash flows at specific times (up positive, down negative). The cash flow diagrams for each relationship are shown in Fig. 2.1. These relationships form the basis for many complicated engineering economy studies involving the time value of money, and many texts specifically address this subject.

Most engineering economy problems are more complicated than the examples we have considered and must be broken down into parts. Example 2.3 illustrates how this is done and demonstrates the use of the other equivalency relationships.

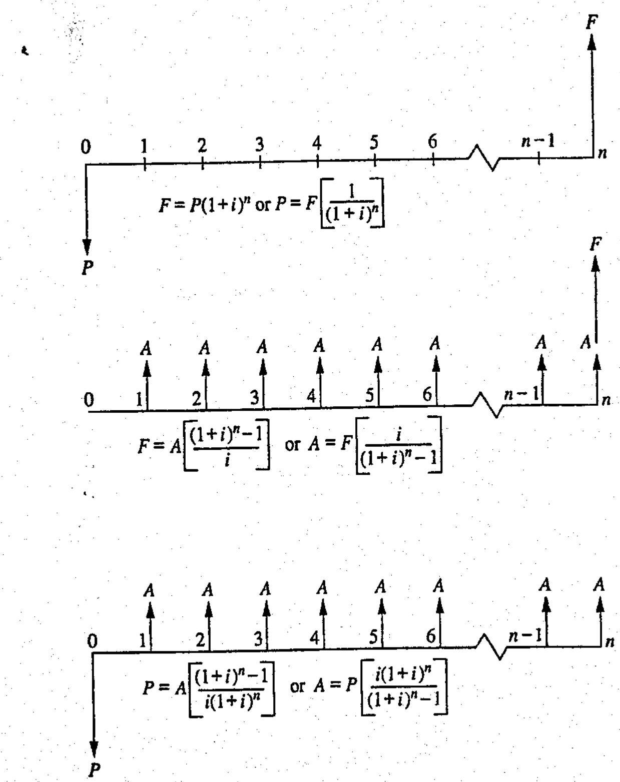


FIGURE 2.1 Cash flow diagrams.

EXAMPLE 2

A machine cost \$45,000 to purchase. Fuel, oil, grease (FOG), and minor maintenance are estimated to cost \$12.34 per operating hour (those hours when the engine is operating and the machine is doing work). A set of tires cost \$3,200 to replace, and their estimated life is 2,800 use hours. A \$6,000 major repair will probably be required after 4,200 hr of use. The machine is expected to last for 8,400 hr, after which it will be sold at a price (salvage value) equal to 10% of the original purchase price. A final set of new tires will not be purchased before the sale. How much should the owner of the machine charge per hour of use, if it is expected that the machine will operate 1,400 hr per year? The company's cost of capital rate is 7%. First solve for n, the life

$$n = \frac{8{,}400\text{ hr}}{1{,}400\text{ hr per yr}} = 6\text{ yr}$$

Usually ownership and operating cost components are calculated separately. Tires are considered an operating cost element because they wear out much faster than the basic machine. Therefore, before calculating the ownership cost of a machine having pneumatic tires, the cost of the tires should be subtracted from the purchase price.

$$\$45{,}000 - \$3{,}200 = \$41{,}800$$

Now the annualized purchase expense can be calculated using the *uniform series capital recovery factor*:

$$A_{\text{ownership}} = \$41{,}800\left[\frac{0.07(1+0.07)^6}{(1+0.07)^6-1}\right] = \$41{,}800 \times 0.209796 = \$8{,}769.46$$

Salvage value at the end of 6 yr is

$$\$45{,}000 \times 0.1 = \$4{,}500$$

The annualized *value* of the salvage amount 6 yr in the future can be calculated using the *uniform series sinking fund factor*:

$$A_{\text{salvage}} = \$4{,}500\left[\frac{0.07}{(1+0.07)^6-1}\right] = \$4{,}500 \times 0.139796 = \$629.08$$

The annualized *value* of the salvage amount 6 yr in the future can also be calculated using the *present worth compound amount factor* with the *uniform series capital recovery factor*:

$$A_{\text{salvage}} = \left[\frac{\$4{,}500}{(1+0.07)^6}\right]\left[\frac{0.07(1+0.07)^6}{(1+0.07)^6-1}\right] = \$629.08$$

The annual FOG and minor maintenance cost is

$$\$12.34 \text{ per hr} \times 1{,}400 \text{ hr per yr} = \$17{,}276.00$$

In addition to the original set of tires, two sets of replacement tires will have to be purchased, one set 2 yr into the life of the machine and a second set 4 yr into the life. To annualize the tire replacement cost, these future-point-in-time costs must be made equivalent to a present amount at time zero, and then the resulting amount is annualized across the 6-yr life of the machine. To do this, use the *present worth compound amount factor* with the *uniform series capital recovery factor*:

$$A_{\text{tires}} = \left[\$3{,}200 + \frac{\$3{,}200}{(1+0.07)^2} + \frac{\$3{,}200}{(1+0.07)^4}\right]\left[\frac{0.07(1+0.07)^6}{(1+0.07)^6-1}\right]$$
$$= (\$3{,}200.00 + \$2{,}795.00 + 2{,}441.26)(0.209796) = \$1{,}769.89$$

The annualized cost for the major repair 3 yr into the life is

$$A_{\text{major repair}} = \left[\frac{\$6{,}000}{(1+0.07)^3}\right]\left[\frac{0.07(1+0.07)^6}{(1+0.07)^6-1}\right]$$
$$= (\$4{,}897.79)(0.209796) = \$1{,}027.54$$

The resulting total annual cost is

$$A_{\text{total}} = \$8{,}769.46 - \$629.08 + \$17{,}276.00 + \$1{,}769.89 + \$1{,}027.54$$
$$= \$28{,}213.81$$

The total cost per hour is

$$\text{Total cost} = \frac{\$28{,}213.81 \text{ per yr}}{1{,}400 \text{ hr per yr}} = \$20.153 \text{ per hr}$$

COST OF CAPITAL

The interest rate a company experiences is really a weighted average rate resulting from the combined cost associated with all external and internal sources of capital funds—debt (borrowing), equity (sale of stock), and retained earnings (internally generated funds). Furthermore, the cost-of-capital interest rate a company experiences is affected by the risk associated with its business type. The market perceives the risk of the business and applies an after-tax discount rate to the future wealth it expects to derive from the firm. Therefore, the rate that banks charge for borrowed funds cannot be taken alone as the company's cost-of-capital interest rate when evaluating investment alternatives. For a complete treatment of cost of capital, see Modigliani and Miller's classic paper published in *The American Economic Review* [5].

Many discussions of equipment economics include *interest* as a cost of ownership. Sometimes the authors make comparisons with the interest rates that banks charge for borrowed funds or with the rate that could be earned if the funds were invested elsewhere. Such comparisons imply that these are appropriate rates to use in an equipment cost analysis. A few authors appear to have perceived the proper character of interest by realizing that a company requires capital funds for all of its operations. It is not logical to assign different interest costs to machines purchased wholly with retained earnings (cash) as opposed to those purchased with borrowed funds. A single interest rate should be determined by examination of the combined costs associated with all sources of capital funds: debt, equity, and retained earnings.

There are two parts to the common misunderstanding concerning the proper way to account for interest. First, as just discussed, the correct interest rate should reflect the combined effect of the costs associated with all capital funds. The second error comes in trying to recoup *interest costs*. Interest is not a cost to be added together with purchase expense, taxes, and insurance when calculating the total cost of a machine.

This might be easier to understand using an analogy. Consider the situation of a banker trying to decide if a loan should be granted. The question before the banker is one of *risk*: what are the chances the money will be repaid? Based on the perceived risk, a decision is made on how much return must be received to *balance* the risk. If a hundred loans are made, the banker knows some will not be repaid. Those borrowers who repay their loans as promised have to provide the total profit margin for the bank. The good loans must carry the bad loans. A company utilizing equipment should be making a similar analysis every time a decision is made to invest in a piece of equipment.

Based on the risk of the construction business, interest is the fulcrum for determining if the value a machine will create for the company is sufficient. The proper interest rate will ensure that this ratio of gain in value to cost is correctly accounted for in the decision process.

The interest rate at issue is referred to in the economic literature as the *cost of capital* to the company and a market value technique has been developed for its calculation. A complete development of the market value cost-of-capital calculation is beyond the scope of this text, but Reference 4 at the end this chapter is a good presentation of the subject. The resulting cost-of-capital rate is the correct interest rate to use in economic analyses of equipment decisions.

EVALUATING INVESTMENT ALTERNATIVES

The purchase, rental, or replacement of a piece of equipment is a financial investment decision, and as such the real question is how best to use a company's assets. Financial investment decisions are analyzed using time value of money principles. Such analyses require an input interest rate or the calculation of the interest rate that results from the assumed cash flows.

Discounted-Present-Worth Analysis

A discounted-present-worth analysis involves calculating the *equivalent* present worth or present value of all the dollar amounts involved in each of the individual alternates to determine the present worth of the proposed alternates. The present worth is discounted at a predetermined rate of interest i, often termed the minimum attractive rate of return (MARR). The MARR is usually equal to the current *cost-of-capital* rate for the company. Example 2.4 illustrates the use of a discounted-present-worth analysis to evaluate three mutually exclusive investment alternatives.

EXAMPLE 2.4

Ace Builders is considering three different acquisition methods for obtaining pickup trucks. The alternatives are

A. Immediate cash purchase the trucks for \$16,800 each, and after 4 yr sell each truck for an estimated \$5,000.

B. Lease the trucks for 4 yr for \$4,100 per year paid in advance at the beginning of each year. The contractor pays all operating and maintenance costs for the trucks, and the leasing company retains ownership.

C. Purchase the trucks using a time payment plan requiring an immediate down payment of \$4,000 and \$4,500 per year at the end of each year for 3 yr. Assume the trucks will be sold after 4 yr for \$5,000 each.

If the contractor's MARR is 8%, which alternative should be used? To solve, calculate the net present worth (NPW) of each alternative using an 8% interest rate and select the least costly alternative.

For the A alternative, use the present worth compound amount factor to calculate the equivalent salvage value at time zero. Add the purchase price, which is negative because it is a cash outflow, and the equivalent salvage value, which is positive because it is a cash inflow. The result is the net present worth of alternative A:

$$\text{NPW}_A = -\$16{,}800 + \frac{\$5{,}000}{\text{PWCAF}}$$

Calculating the PWCAF with i equal to 8% and n equal to 4,

$$\text{NPW}_A = -\$16{,}800 + \frac{\$5{,}000}{1.360489} = -\$13{,}124.85$$

For alternative B, use the uniform series present worth factor to calculate the time-zero equivalent value of the future lease payments, and add to that result the value of the initial lease payment; both of these are negative because they are cash outflows. There is no salvage in this case, as the leasing company retains ownership of the trucks.

$$\text{NPW}_B = -\$4{,}100 - \$4{,}100\ (\text{USPWF})$$

Calculating the USPWF with i equal to 8% and n equal to 4,

$$\text{NPW}_B = -\$4{,}100 - \$4{,}100\left[\frac{0.259712}{0.100777}\right] = -\$14{,}666.10$$

For alternative C use the uniform series present worth factor to calculate the time-zero equivalent value of the future payments and the present worth compound amount factor to calculate the equivalent salvage value at time zero. Add the three values, the initial payment and the equivalent annual payment both being negative and the salvage being positive, to arrive at the net present worth of alternate C.

$$\text{NPW}_C = -\$4{,}000 - \$4{,}500\ (\text{USPWF}) + \left[\frac{\$5{,}000}{\text{PWCAF}}\right]$$

$$\text{NPW}_C = -\$4{,}000 - \$4{,}500\left[\frac{0.259712}{0.100777}\right] + \left[\frac{\$5{,}000}{1.360489}\right] = -\$11{,}921.79$$

The least costly alternative is C.

Example 2.4 was simplified in two respects. First, the number of calculations required was quite small. Second, all three alternatives involved the same time duration (4-yr lives in the example). Problems involving more data may require more calculations, but the analysis approach is the same as shown in Example 2.4. When the alternatives involve different time durations (machines have different expected durations of usefulness), the analysis must be modified to account for the different time durations. Obviously, if a comparison is made of one alternative having a life of 5 yr and another with a life of 10 yr, the respective discounted present worths are not directly comparable. How is such a situation handled? There are two approaches that are generally used.

Approach 1. Truncate (cut off) the longer-lived alternative(s) to equal the shorter-lived alternative and assume a salvage value for the unused portion of the longer-lived alternative(s). Then make the comparison on the basis of equal lives.

Approach 2. Compute the discounted present worth on the basis of the least common denominator of the different alternatives' lives.

ELEMENTS OF OWNERSHIP COST

Ownership cost is the cumulative result of those cash flows an owner experiences whether or not the machine is productively employed on a job. It is a cost related to finance and accounting exclusively, and it does not include the wrenches, nuts and bolts, and consumables necessary to keep the machine operating.

Most of ownership cash flows are expenses (outflows), but a few are cash inflows. The most significant cash flows affecting *ownership cost* are

1. Purchase expense
2. Salvage value
3. Tax saving from depreciation
4. Major repairs and overhauls
5. Property taxes
6. Insurance
7. Storage and miscellaneous

Purchase Expense

The cash outflow the firm experiences in acquiring ownership of a machine is the purchase expense. It is the total delivered cost (drive-away cost), including amounts for all options, shipping, and taxes, less the cost of tires if the machine has pneumatic tires. The machine will show as an asset in the firm's accounting records. The firm has exchanged money (dollars), a liquid asset, for a machine, a fixed asset with which the company hopes to generate profit. As the machine is used on projects, wear takes its toll and the machine can be thought of as being used up or consumed. This consumption reduces the machine's value because the revenue stream it can generate is likewise reduced. Normally, an owner tries to account for the decrease in value by prorating the consumption of the investment over the *service life* of the machine. This prorating is known as depreciation.

It can be argued that the amount that should be prorated is the difference between the initial acquisition expense and the expected future salvage value. Such a statement is correct to the extent of accounting for the amounts involved, but it neglects the timing of the cash flows. Therefore, it is recommended that each cash flow be treated separately to allow for a time value analysis and to allow for ease in changing assumptions during sensitivity analyses.

Salvage Value

Salvage value is the cash inflow a firm receives if a machine still has value at the time of its disposal. This revenue will occur at a future date.

Used equipment prices are difficult to predict. Machine condition (see Fig. 2.2), the movement of new machine prices (see Fig. 2.3), and the machine's possible secondary service applications affect the amount an owner can expect to receive. A machine having a diverse and layered service potential will command a higher resale value. Medium-size dozers, which often exhibit rising salvage values in later years, can have as many as seven different levels of useful life. These may range from an initial assignment as a high-production machine on a dirt spread to an infrequent land-clearing assignment by a farmer.

Historical resale data can provide some guidance in making salvage value predictions and can be fairly easily accessed from auction price books. By studying such historical data and recognizing the effects of the economic environment, the magnitude of salvage value prediction errors can be minimized and the accuracy of an ownership cost analysis improved.

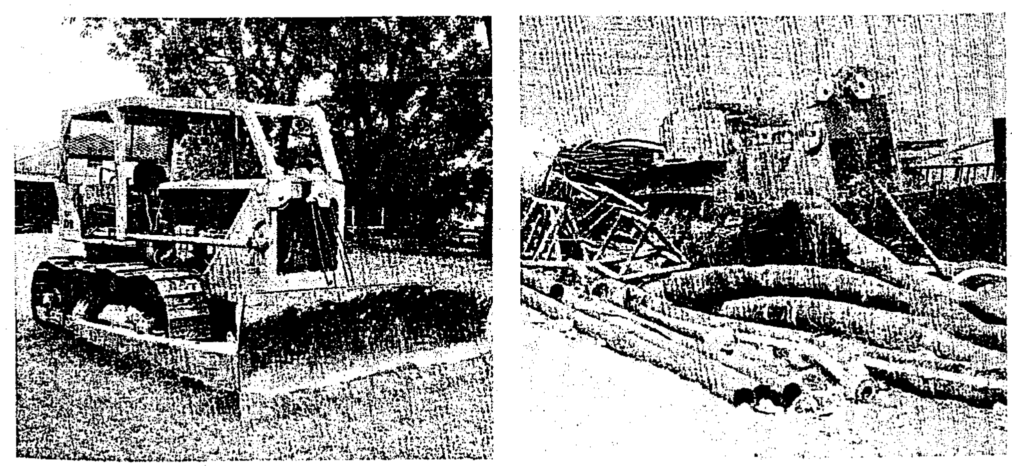


FIGURE 2.2 Salvage value is dependent on machine condition.

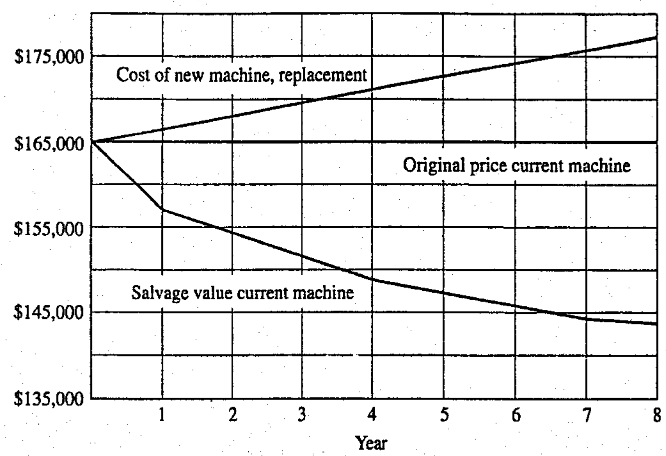


FIGURE 2.3 The movement of new machine prices –cost– is one factor affecting salvage value.

Tax Savings from Depreciation

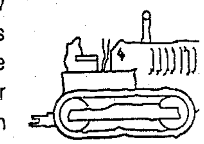
The tax savings from depreciation are a phenomenon of the tax system in the United States. (This may not be an ownership cost factor under the tax laws in other countries.) Under the tax laws of the United States, depreciating a machine's loss in value with age will lessen the net cost of machine ownership. The cost saving, the prevention of a cash outflow, afforded by tax depreciation is a result of shielding the company from taxes. This is an applicable cash flow factor only if a company is operating at a profit. There are carry-back features in the tax law so that the saving can be preserved even though there is a loss in any one particular year, but the long-term operating position of the company must be at a profit for tax saving from depreciation to come into effect.

The rates at which a company can depreciate a machine are set by the revenue code. These rates usually have no relation to actual consumption of the asset (machine). Therefore, many companies keep several sets of depreciation numbers, one for depreciation tax purposes, one for corporate earnings tax accounting purposes, and one for internal and/or financial statement purposes. The first two are required by the revenue code. The last tries to accurately match the consumption of the asset based on work application and company maintenance policies.

Under the current tax laws, tax depreciation accounting no longer requires the assumption of a machine's future salvage value and useful life. The only piece of information necessary is basis. Basis refers to the cost of the machine for purposes of computing gain or loss. Basis is essential. To compute tax depreciation amounts, fixed percentages are applied to unadjusted basis. The terminology adjusted/unadjusted refers to changing the book value of a machine by depreciation.

The tax law allows the postponement of taxation on gains derived from the exchange of like-kind depreciable property. If there is a gain realized from a like-kind exchange, the depreciation basis of the new machine is reduced by the amount of the gain. However, if the exchange involves a disposal sale to a third party and a separate acquisition of the replacement, the gain from the sale is taxed as ordinary income.

EXAMPLE 2.



A tractor with an adjusted basis (from depreciation) of $25,000 is traded for a new tractor that has a fair market value of $400,000. A cash payment of $325,000 is made to complete the transaction. Such a transaction is a nontaxable exchange and no gain is recognized on the trade-in. The unadjusted basis of the new tractor is $350,000, even though the cash payment was $325,000 and the apparent gain in value for the traded machine was $50,000 [($400,000 − $325,000) − $25,000].

Cash payment	$325,000
Adjusted basis of the trade-in tractor	25,000
Basis of the new tractor	$350,000

If the owner had sold the old tractor to a third party for $75,000 and then purchased a new tractor for $400,000, the $50,000 profit on the third-party sale would have been taxed as ordinary income and the unadjusted basis of the new tractor would be $400,000.

The current tax depreciation law establishes depreciation percentages that can be used based on the specific year of machine life. These are usually the optimum depreciation rates in terms of tax advantages. However, an owner can still utilize the straight-line method of depreciation or methods that are not expressed in terms of time duration (years). Unit-of-production would be an example of a depreciation system that is not time based.

Straight-Line Depreciation Straight-line depreciation is easy to calculate. The annual amount of depreciation D_n, for any year n, is a constant value, and thus the book value (BV_n) decreases at a uniform rate over the useful life of the machine. The equations are

$$\text{Depreciation rate, } R_n = \frac{1}{N} \quad [2.7]$$

where N = number of years.

$$\text{Annual depreciation amount, } D_n = \text{Unadjusted basis} \times R_n$$

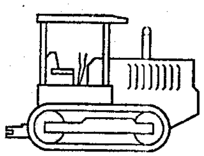
Substituting Eq. [2.7] yields

$$D_n = \frac{\text{Unadjusted basis}}{N} \quad [2.8]$$

$$\text{Book value year } m\text{, } BV_n = \text{Unadjusted basis} - (n \times D_n) \quad [2.9]$$

m	BV_{n-1}	D_n	BV_n
0	$ 0	$ 0	$350,000
1	350,000	70,000	280,000
2	280,000	70,000	210,000
3	210,000	70,000	140,000
4	140,000	70,000	70,000
5	70,000	70,000	0

EXAMPLE 2.6



Consider the new tractor in Example 2.5 and assume it has an estimated useful life of 5 yr. Determine the depreciation and the book value for each of the 5 yr using the straight-line method.

$$\text{Depreciation rate, } R_n = \frac{1}{5} = 0.2$$

Annual depreciation amount, D_n = \$350,000 × 0.2 = \$70,000

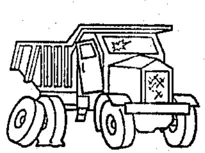
Tax Code Depreciation Schedules Under the tax code, machines are classified as 3-, 5-, 10-, or 15-yr real property. Cars and light-duty trucks (under 13,000 lb unloaded) are classified as 3-yr property. Most other pieces of construction equipment are 5-yr property. The appropriate depreciation rates are given in Table 2.1.

If a machine is disposed of before the depreciation process is completed, no depreciation can be recovered in the year of disposal. Any gain, as measured against the depreciated value or adjusted basis, is treated as ordinary income.

TABLE 2.1 Tax code specified depreciation rates.

Year of life	3-yr property	5-yr property
1	0.33	0.20
2	0.45	0.32
3	0.22	0.24
4	—	0.16
5	—	0.08

EXAMPLE 2.7



A 5-yr life class machine is purchased for \$125,000. It is sold in the third year after purchase for \$91,000. Using the tax code specified depreciation rates, what are the depreciation amounts and what is the book value of the machine when it is sold? Will there be income tax, if so on what amount?

\$125,000 × 0.20 = \$25,000 depreciation at end of the first year
\$125,000 × 0.32 = \$40,000 depreciation at end of the second year
\$65,000 total depreciation

Book value when sold = \$125,000 + \$65,000 = \$60,000.

The amount of gain on which there will be a tax is

\$91,000 − \$60,000 = \$31,000

The tax savings from depreciation are influenced by

1. Disposal method for the old machine
2. Value received for the old machine
3. Initial value of the replacement
4. Class life
5. Tax depreciation method

Based on the relationships between these elements, three distinct situations are possible:

1. No gain on the disposal—no income tax on zero gain.
2. A gain on the disposal:
   a. Like-kind exchange—no added income tax, but basis for the new machine is adjusted.
   b. Third-party sale—the gain is taxed as income; the basis of the new machine is fair market value paid.
3. A disposal in which a loss results—the basis of the new machine is the same as the basis of the old machine, decreased by any money received.

Assuming a corporate profit situation, the applicable tax depreciation shield formulas are

1. For a situation where there is no gain on the exchange:

$$\text{Total tax shield} = \sum_{n=1}^{N} t_c D_n \qquad [2.10]$$

where

n = individual yearly time periods within a life assumption of N years
t_c = corporate tax rate
D_n = annual depreciation amount in the nth time period

2. For a situation where a gain results from the exchange
   a. Like-kind exchange—Eq. [2.10] is applicable. It must be realized that the basis of the new machine will be affected.
   b. Third-party sale.

$$\text{Total tax shield} = \left(\sum_{n=1}^{N} t_c D_n\right) - \text{gain} \times t_c \qquad [2.11]$$

Gain is the actual salvage amount received at the time of disposal minus the book value.

The implication of the basis is that in making analysis calculations, the actual salvage derived from the machine directly affects the depreciation saving. To perform a valid analysis, the depreciation accounting practices for tax purposes and the methods of machine disposal and acquisition the company chooses to use must be carefully examined. These dictate the appropriate calculations for the tax effects of depreciation.

Major Repairs and Overhauls

Major repairs and overhauls are included under ownership cost because they result in an extension of a machine's service life. They can be considered as an investment in a new machine. Because a machine commonly works on many different projects, considering major repairs as an ownership cost prorates these expenses to all jobs. These costs should be added to the basis of the machine and depreciated.

Taxes

In this context, taxes refer to those equipment ownership taxes that are charged by any government subdivision. They are commonly assessed at a percentage rate applied against the book value of the machine. Depending on location, property taxes can range up to about 4.5% of assessed machine value. In many locations, there will be no property tax on equipment. Over the service life of the machine, they will decrease in magnitude as the book value decreases.

Insurance

Insurance, as considered here, includes the cost to cover fire, theft, and damage to the equipment. Annual rates can range from 1 to 3%. This cost can be actual premium payments to insurance companies, or it can represent allocations to a self-insurance fund maintained by the equipment owner.

Storage and Miscellaneous

Between jobs or during bad weather, a company will require storage facilities for its equipment. The cost of maintaining storage yards and facilities should be prorated to those machines that require such harborage. Typical expenses include space rental, utilities, and the wages for laborers or watchmen. Usually these expenses are all combined in an overhead account and then allocated on a proportional basis to the individual machines. The rate may range from nothing to perhaps 5%.

ELEMENTS OF OPERATING COST

Operating cost is the sum of those expenses an owner experiences by working a machine on a project. Typical expenses include

1. Fuel
2. Lubricants, filters, and grease

3. Repairs
4. Tires
5. Replacement of high-wear items

Operator wages are sometimes included under operating costs, but because of wage variances between projects, the general practice is to keep operator wages as a separate cost category. Such a procedure aids in estimation of machine cost for bidding purposes as the differing project wage rates can readily be added to the total machine O&O cost. In applying operator cost, all benefits paid by the company must be included—direct wages, fringe benefits, insurance, etc. This is another reason wages are separated. Some benefits are based on an hourly basis, some on a percentage of income, some on a percentage of income to a maximum amount, and some are paid as a fixed amount. The assumptions about project work schedule will therefore affect wage expense.

Fuel

Fuel expense is best determined by measurement on the job. Accurate service records tell the owner how many gallons of fuel a machine consumes over what period of time and under what job conditions. Hourly fuel consumption can then be calculated directly.

When company records are not available, manufacturer's consumption data can be used to construct fuel use estimates. The amount of fuel required to power a piece of equipment for a specific period of time depends on the brake horsepower of the machine and the specific work application. Therefore, most tables of hourly fuel consumption rates are divided according to the machine type and the working conditions. To calculate hourly fuel cost, a consumption rate is found in the tables (see Table 2.2) and then multiplied by the unit price of fuel. The cost of fuel for vehicles used on public highways will include applicable taxes. However, in the case of off-road machines used exclusively on project sites there is usually no fuel tax. Therefore, because of the tax laws, the price of gas or diesel will vary with machine usage.

TABLE 2.2 Average fuel consumption—wheel loaders.

	Type of utilization		
Horsepower (fwhp)	Low (gal/hr)	Medium (gal/hr)	High (gal/hr)
90	1.5	2.4	3.3
140	2.5	4.0	5.3
220	5.0	6.8	9.4
300	6.5	8.8	11.8

Note fwhp is flywheel horsepower.

Fuel consumption can also be calculated on a theoretical basis. The resulting theoretical values must be adjusted by *time and load factors* that account for working conditions. This is because the theoretical formulas are derived assuming that the engine is operating at maximum output. Working conditions that must be considered are the percentage of an hour that the machine is actually working (*time factor*) and at what percentage of rated horsepower (*throttle load factor*). When operating under standard conditions, a *gasoline engine* will consume approximately 0.06 gal of fuel per flywheel horsepower hour (fwhp-hr). A *diesel engine* will consume approximately 0.04 gal per fwhp-hr.

Lubricants—Lube Oils, Filters, and Grease

The cost of lube oils, filters, and grease (see Fig. 2.4) will depend on the maintenance practices of the company and the conditions of the work location. Some companies follow machine manufacturer's guidance concerning time periods between lubricant and filter changes. Other companies have established their own preventive maintenance change period guidelines. In either case, the hourly cost is arrived at by (1) considering the operating hour duration between changes and the quantity required for a complete change plus (2) a small consumption amount representing what is added between changes.

Many manufacturers provide quick cost estimating tables or rules for determining the cost of these items. Whether using manufacturer's data or past experience, notice should be taken about whether the data matches expected field conditions. If the machine is to be operated under adverse conditions, such as deep mud, water, or sever dust, the data values will have to be adjusted.

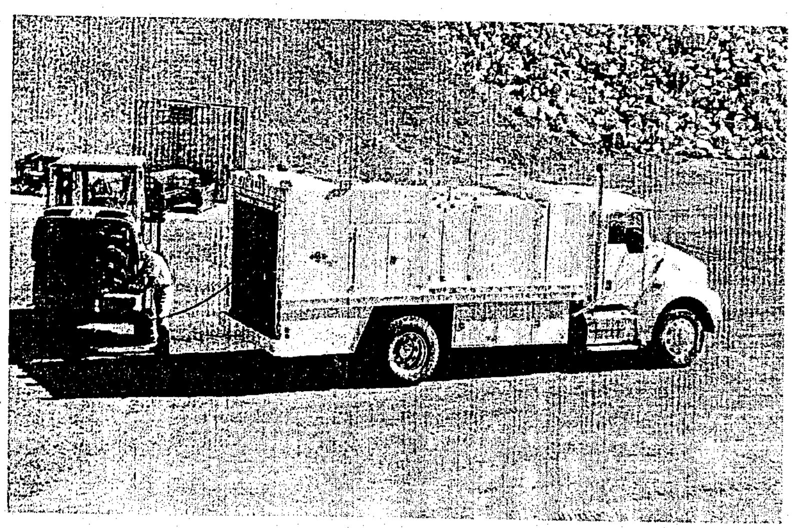


FIGURE 2.4 Checking the oil on a small loader.

A formula that can be used to estimate the quantity of oil required is

$$\begin{array}{c}\text{Quantity consumed,}\\ \text{gph (gal per hour)}\end{array} = \frac{\text{hp} \times f \times 0.006\ \text{lb/hp} - \text{hr}}{7.4\ \text{lb/gal}} + \frac{c}{t} \qquad [2.12]$$

where

hp = rated horsepower of the engine
c = capacity of the crankcase in gallons
f = operating factor
t = number of hours between oil changes

This formula contains the assumption that the quantity of oil consumed per rated horsepower hour between changes will be 0.006 lb.

Repairs

Repairs, as referred to here, mean normal maintenance-type repairs (see Fig. 2.5). These are the repair expenses incurred on the job site where the machine is operated and would include the costs of parts and labor. Major repairs and overhauls are an ownership cost.

FIGURE 2.5 Normal repairs are included in operating cost.

Repair expenses increase with machine age. The army has found that 35% of its equipment maintenance cost is directly attributable to the oldest 10% of its equipment. Instead of applying a variable rate, an average is usually calculated by dividing the total expected repair cost, for the planned service life of the machine, by the planned operating hours. Such a policy builds up a repair reserve during a machine's early life. That reserve will then be used to cover the higher costs experienced later. As with all costs, company records are the best source of expense information. When such records are not available, manufacturers' published guidelines can be used.

Tires

Tires for wheel-type equipment (see Fig. 2.6) are a major operating cost because they have a short life in relation to the "iron" of a machine. Tire cost will include repair and replacement charges. These costs are very difficult to estimate because of the variability in tire wear with project site conditions and operator skill. Both tire and equipment manufacturers publish tire life guidelines based on tire type and job application. Manufacturers' suggested life periods can be used with local tire prices to obtain an hourly tire cost. It must be remembered, however, that the guidelines are based on good operating practices and do not account for abuses such as overloading haul units.

Replacement of High-Wear Items

The cost of replacing those items that have very short service lives in relation to machine service life can be a critical operating cost. These items will differ depending on the type of machine, but typical items include cutting edges, ripper tips, bucket teeth (see Fig. 2.7), body liners, and cables. By using either past experience or manufacturer life estimates, the cost can be calculated and converted to an hourly basis.

All machine-operating costs should be calculated per working hour. That way it is easy to sum the applicable costs for a particular class of machines and obtain a total operating hour cost.

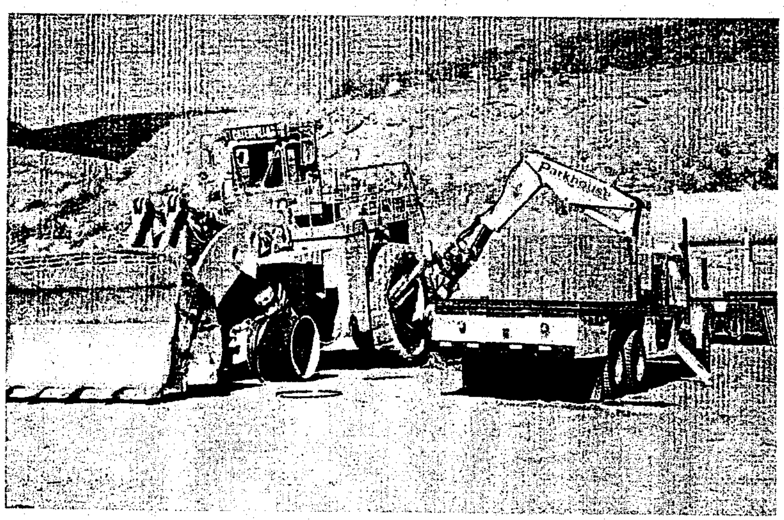


FIGURE 2.6 Tires are a major operating cost.

FIGURE 2.7 Bucket teeth are a high-wear item replacement cost.

COST FOR BIDDING

The process of selecting a particular type of machine for use in constructing a project requires knowledge of the cost associated with operating the machine in the field. In selecting the proper machine, a contractor seeks to achieve unit production at the least cost. For project bidding and cost accounting, we are interested in a machine's ownership and operating cost. O&O costs are usually expressed in dollars per equipment operating hour.

Ownership Cost

The expense of purchasing a machine and the inflow of money in the future (when the machine is retired from service) are the two most significant components of ownership cost. The net result of these two cash flows, which defines the machine's decline in value across time, is termed depreciation. As used in this section, depreciation is the measuring system used to account for purchase expense at time zero and salvage value after a defined period of time. Depreciation is expressed on an hourly basis over the service life of a machine. Do not confuse the depreciation discussed here with tax depreciation. Tax depreciation has nothing to do with consumption of the asset; it is simply an artificial calculation for tax code purposes.

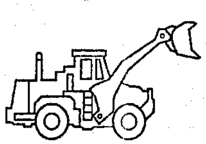
> Because tires are a high-wear item that will be replaced many times over a machine's service life, their cost will be not be included in these calculations but will be addressed as a part of operating cost.

The depreciation portion of ownership cost can be calculated by either of two methods: time value or average annual investment.

Depreciation—Time Value Method The time value method will recognize the timing of the cash flows, i.e., the purchase at time zero and the salvage at a future data. The cost of the tires is deducted from the total purchase price, which includes amounts for all options, shipping, and taxes (total cash outflow − cost of tires). A judgment about the expected service life and a corporate cost of capital rate are both necessary input parameters for the analysis. To determine the machine's purchase price equivalent annual cost the uniform series capital recovery factor formula, Eq. [2.6], is used. The input parameters are the purchase price at time zero (P), expected service life (n), and the corporate cost of capital rate (i).

To account for the salvage cash inflow, Eq. [2.4], the uniform series sinking fund factor formula, is utilized. The input parameters are the estimated future salvage amount (F), the expected service life (n), and the corporate cost of capital rate (i).

EXAMPLE 2.8



A company having a cost of capital rate of 8% purchases a $300,000 loader. This machine has an expected service life of 4 yr and will be utilized 2,500 hr per year. The tires on this machine cost $45,000. The estimated salvage value at the end of 4 yr is $50,000. Calculate the depreciation portion of the ownership cost for this machine using the time value method.

Initial cost	$300,000
Cost of tires	−45,000
Purchase price less tires	$225,000

Calculate the equivalent uniform period series required to replace a present value of $255,000. Using Eq. [2.6],

$$A = \$255{,}000\left[\frac{0.08(1+0.08)^4}{(1+0.08)^4-1}\right]$$

$$= \$255{,}000 \times 0.3019208 = \$76{,}990 \text{ per year}$$

Calculate the equivalent uniform end-of-period investments that equal the future salvage value. Using Eq. [2.4],

$$A = \$50{,}000\left[\frac{0.08}{(1+0.08)^4-1}\right]$$

$$= \$50{,}000 \times 0.02219208 = \$11{,}096 \text{ per year}$$

Therefore, using the time value method the hourly depreciation portion of the machine's ownership cost is

$$\frac{\$76{,}990/\text{yr} - \$11{,}096/\text{yr}}{2{,}500 \text{ hr/yr}} = \$26.358/\text{hr}$$

Depreciation—Average Annual Investment Method A second approach to calculating the depreciation portion of ownership cost is the average annual investment (AAI) method.

$$\text{AAI} = \frac{P(n+1) + S(n-1)}{2n} \qquad [2.13]$$

where

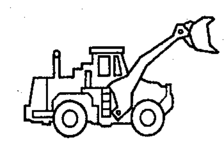
P = purchase price less the cost of the tires

S = the estimated salvage value

n = expected service life in years

The AAI is multiplied by the corporate cost of capital rate to determine the cost of money portion of depreciation. The straight-line depreciation of the cost of the machine less the salvage and less the cost of tire, if a pneumatic-tired machine, is then added to the cost of money portion (interest) to arrive at the total amount of ownership depreciation.

EXAMPLE 2.9



Using the same machine and company information as in Example 2.8, calculate the ownership depreciation using the AAI method.

$$\text{AAI} = \frac{\$255{,}000(4+1) + \$50{,}000(4-1)}{2 \times 4}$$

$$= \$178{,}125/\text{yr}$$

$$\text{Cost of money portion} = \frac{\$178{,}125/\text{yr} \times 8\%}{2{,}500 \text{ hr/yr}} = \$5.700/\text{hr}$$

Straight-line depreciation portion

Initial cost	$300,000
Cost of tires	−45,000
Salvage	−50,000
	$205,000

$$\frac{\$205{,}000}{4 \text{ yr} \times 2{,}500 \text{ hr/yr}} = \$20.500/\text{hr}$$

Total ownership depreciation using the AAI method

$$\$5.700/\text{hr} + \$20.500 = \$26.200/\text{hr}$$

For Examples 2.8 and 2.9, the difference in the calculated depreciation portion of the ownership cost is \$0.158/hr (\$26.358/hr − \$26.200/hr). The choice of which method to use is strictly a company preference, however, all analyses should use the same method. Basically, either method is satisfactory, especially considering the impact of the unknowns concerning service life, operating hours per year, and expected future salvage. There is no single solution to calculating ownership cost. The best approach is to perform several analyses using different assumptions and to be guided by the range of solutions.

Tax Saving from Tax Code Depreciation To calculate the tax saving from depreciation, the government tax code depreciation schedules (Table 2.1) must be used. The resulting depreciation amounts are then multiplied by the company's tax rate to calculate specific savings, using Eq. [2.10] or Eq. [2.11]. The sum of the yearly saving must be divided by the total anticipated operating hours to obtain an hourly cost saving.

EXAMPLE 2.10

Using the same machine and company information as in Example 2.8, calculate the hourly tax saving resulting from tax code depreciation. Assume that under the tax code the machine is a 5-yr property and that there had been no gain on the exchange that procured the machine. The company's tax rate is 37%.

First, calculate the annual depreciation amounts for each of the years. In this case, the tax code depreciation rate must be used to calculate the depreciation.

Year	5-yr property rates	BV_{n-1}	D_n	BV_n
0		\$ 0	\$ 0	\$300,000
1	0.20	300,000	60,000	240,000
2	0.32	240,000	96,000	144,000
3	0.24	144,000	72,000	72,000
4	0.16	72,000	48,000	24,000
5	0.08	24,000	24,000	0

Using Eq. [2.10], the tax shielding effect for the machine's service life would be

Year	D_n		Shielded amount*
1	\$60,000		\$22,200
2	96,000		35,520
3	72,000		26,640
4	48,000		17,760
		Total	\$102,120

* $D_n \times 37\%$

$$\text{Tax saving from depreciation} = \frac{\$102,120}{4\ \text{yr} \times 2,500\ \text{hr/yr}} = \$10.21/\text{hr}$$

Major Repairs and Overhauls When a major repair and overhaul takes place, the machine's ownership cost will have to be recalculated. This is done by adding the cost of the overhaul to the book value at that point in time. The resulting new adjusted basis is then used in the depreciation calculated, as already described. If there are separate calculations for true depreciation and for tax code depreciation, both will have to be adjusted.

Taxes, Insurance, and Storage To calculate the taxes, insurance, and storage costs, common practice is to simply apply a percentage value to either the machine's book value or its AAI amount. The expenses incurred for these items are usually accumulated in a corporate overhead account. That value divided by the value of the equipment fleet and multiplied by 100 will provide the percentage rate to be used.

$$\text{Taxes, insurance, and storage portion of ownership cost} = \text{rate}(\%) \times BV_n\ (\text{or AAI}) \qquad [2.14]$$

EXAMPLE 2.11

Using the same machine and company information as in Examples 2.8 and 2.9 calculate the hourly owning expense associated with taxes, insurance, and storage. Annually, the company pays on average 1% in property taxes for equipment, 2% for insurance, and allocates 0.75% for storage expenses.

Total percentage rate for taxes, insurance, and storage

1% + 2% + 0.75% = 3.75%

From Example 2.9, the average annual investment for the machine is \$178,125/yr.

Taxes, insurance, and storage expense

$$\frac{\$178,125/\text{yr} \times 3.75\%}{2,500\ \text{hr/yr}} = \$2.672/\text{hr}$$

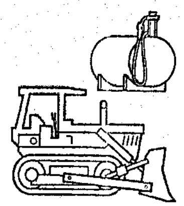
Operating Cost

Figures based on actual company experience should be used to develop operating expenses. Many companies, however, do not keep good equipment operating and maintenance records; therefore, many operating costs are estimated as a percentage of a machine's book value. Even companies that keep records often accumulate expenses in an overhead account and then prorate that total back to individual machines using book value.

Fuel The amount expended on fuel is a product of how a machine is used in the field and the local cost of fuel. In years past, fuel could be purchased on long-term contracts at a fixed price. Today, fuel is usually offered with a *time of delivery price*. A supplier will agree to supply the fuel needs of a project, but the price will not be guaranteed for the duration of the work. Therefore, when bidding a long-duration project, the contractor must make an assessment of future fuel prices.

To calculate hourly fuel expense, a consumption rate is multiplied by the unit price of fuel. Service records are important for estimating fuel consumption.

EXAMPLE 2.12



A 220-fwhp dozer will be used to push aggregate in a stockpile. This dozer is diesel powered. It is estimated that the work will be steady at an efficiency equal to a 50-min hour. The engine will work at full throttle while pushing the load (30% of the time) and at three-quarter throttle to reverse travel and position. Calculate the fuel consumption using the engine consumption averages. If diesel cost $1.07/gal, what is the expected fuel expense?

Fuel consumption diesel engine 0.04 gal per fwhp-hr.

Throttle load factor (operating power):

Push load	1.00 (power) × 0.30 (% of the time) = 0.30
Travel and position	0.75 (power) × 0.70 (% of the time) = 0.53
	0.83

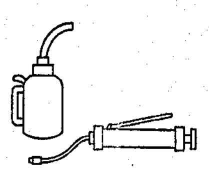
Time factor (operating efficiency): 50-min hour: 50/60 = 0.83

Combined factor: 0.83 × 0.83 = 0.69

Fuel consumption = 0.69 × 0.04 gal/fwhp-hr × 220 fwhp = 6.1 gal/hr

Lubricants The quantity of lubricants used by an engine will vary with the size of the engine, the capacity of the crankcase, the condition of the piston rings, and the number of hours between oil changes. For extremely dusty conditions, it may be desirable to change oil every 50 hr, but this is an unusual condition. It is common practice to change oil every 100 or 200 hr. The quantity of the oil consumed by an engine per change will include the amount added during the change plus the makeup oil between changes.

EXAMPLE 2.13



Calculate the oil required, on a per hour basis, for the 220-fwhp dozer in Example 2.12. The operating factor will be 0.69, as calculated in that example. The crankcase capacity is 8 gal and the company has a policy to change oil every 150 hr.

Quantity consumed, gph (gal per hour) is

$$\frac{220 \text{ fwhp} \times 0.69 \times 0.006 \text{ lb/hp-hr}}{7.4 \text{ lb/gal}} + \frac{8 \text{ gal}}{150 \text{ hr}} = 0.18 \text{ gal/hr}$$

The cost of hydraulic oils, filters, and grease will be added to the expense of engine oil. The hourly cost of filters is simply the actual expense to purchase the filters divided by the hours between changes. If a company does not keep good machine servicing data, it is difficult to accurately estimate the cost of hydraulic oil and grease. The usual solution is to refer to manufacturers' published tables of average usage or expense.

Repairs The cost of repairs is normally the largest single component of machine cost (see Table 2.3). Some general guidelines published, in the past, by the Power Crane and Shovel Association (PCSA) estimated repair and maintenance expenses at 80 to 95% of depreciation for crawler-mounted excavators, 80 to 85% for wheel-mounted excavators, 55% for crawler cranes, and 50% for wheel-mounted cranes. The lower figures for cranes reflect the work they perform and the intermittent nature of their use. The data assumed that half of the cost was materials and parts, and half was labor, in the case of mechanical machines. For hydraulic machines, two-thirds of the cost is for materials and parts, and one-third for labor.

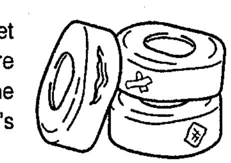
Equipment manufacturers supply tables of average repair costs based on machine type and work application. Repair expenses will increase with machine usage (age). The repair cost to establish a machine rate for bidding should be an average rate.

Tires Tire expenses include both tire repair and tire replacement. Tire maintenance is commonly handled as a percentage of straight-line tire depreciation. Tire hourly cost can be derived simply by dividing the cost of a set of tires by their expected life, and this is how many companies prorate this expense. A more sophisticated approach is to use a time-value calculation recognizing that tire replacement expenses are single point in time outlays that take place over the life of a wheel-type machine.

TABLE 2.3 Breakdown of machine cost over its service life.

Cost category	Percentage of total cost (%)
Repair	37
Depreciation	25
Operating	23
Overhead	15

EXAMPLE 2.14



Calculate the hourly tire cost that should be part of machine operating cost if a set of tires can be expected to last 5,000 hr. Tires cost $38,580 per set of four. Tire repair cost is estimated to average 16% of the straight-line tire depreciation. The machine has a service life of 4 yr and operates 2,500 hr per year. The company's cost of capital rate is 8%.

Not considering the time value of money:

$$\text{Tire repair cost} = \frac{\$38{,}580}{5{,}000 \text{ hr}} \times 16\% = \$1.235/\text{hr}$$

$$\text{Tire use cost} = \frac{\$38{,}580}{5{,}000 \text{ hr}} = \$7.716/\text{hr}$$

Therefore, tire operating cost is $8.951/hr ($1.235/hr + $7.716/hr).

Considering the time value of money:
Tire repair cost is the same \$1.235/hr.
Calculate the number of times the tires will have to be replaced.

$$\left(\frac{4\text{ yr} \times 2{,}500\text{ hr/yr}}{5{,}000\text{ hr per set of tires}}\right) = 2\text{ sets}$$

Will have to purchase a second set at the end of the second year.

First set: Calculate the uniform series required to replace a present value of \$38,580. Using Eq. [2.6],

$$A = \$38{,}580\left[\frac{0.08(1+0.08)^4}{(1+0.08)^4 - 1}\right]$$

$$\frac{\$38{,}580 \times 0.301921}{2{,}500\text{ hr/yr}} = \$4.659/\text{hr}$$

Second set: The second set will be purchased 2 yr in the future. Therefore, what amount at time zero is equivalent to \$38,580 2 yr in the future? Using the present worth compound amount factor (Eq. [2.2]), the equivalent time-zero amount is calculated:

$$P = \frac{\$38{,}580}{(1+0.08)^2} = \$33{,}076$$

Calculate the uniform series required to replace a present value of \$33,076.

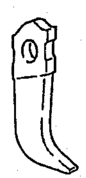
$$A = \$33{,}076\left[\frac{0.08(1+0.08)^4}{(1+0.08)^4 - 1}\right]$$

$$\frac{\$33{,}076 \times 0.301921}{2{,}500\text{ hr/yr}} = \$3.995/\text{hr}$$

Therefore, considering the time value of money, tire operating cost is \$9.889/hr (\$1.235/hr + \$4.659/hr + \$3.995/hr).

High-Wear Items Because the cost of high-wear items is dependent on job conditions and machine application, the cost of these items is usually accounted for separate from general repairs.

EXAMPLE 2.15



A dozer equipped with a three-shank ripper will be used in a loading and ripping application. Actual ripping will take place only about 20% of total dozer operating time. A ripper shank consists of the shank itself, a ripper tip, and a shank protector. The estimated operating life for the ripper tip is 30 hr. The estimated operating life of the ripper shank protector is 3 times tip life. The local price for a tip is \$40 and \$60 for shank protectors. What hourly high-wear item charge should be added to the operating cost of a dozer in this application?

Tips: $\frac{30\text{ hr}}{0.2} = 150\text{ hr of dozer operating time}$

$$\frac{3 \times \$40}{150\text{ hr}} = \$0.800/\text{hr for tips}$$

Shank protectors: 3 times tip life × 150 hr = 450 hours of dozer operating time

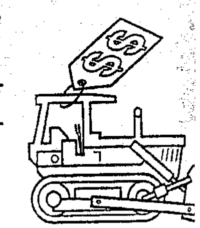
$$\frac{3 \times \$60}{450\text{ hr}} = \$0.400/\text{hr for shank protectors}$$

Therefore, cost of high-wear items is \$1.200/hr (\$0.800/hr tips + \$0.400/hr shank protectors).

REPLACEMENT DECISIONS

A piece of equipment has two lives: (1) a physically limited working life and (2) a cost-limited economic life. Because equipment owners are in business to make money, the economic life of their equipment is of critical importance. A machine in good mechanical condition and working productively enjoys a strong bias in favor of its retention in the equipment inventory. The equipment manager may look only at the high initial cash outflow associated with the purchase of a replacement machine and consequently ignore the other cost factors involved. All cost factors must be examined when considering a replacement decision. A simple example will help to illustrate the concept.

EXAMPLE 2.



A small dozer is purchased for \$106,000. A forecast of expected operating hours, salvage values, and maintenance expense is presented in the table.

Year	Operating hours	Salvage (\$)	Maintenance expense (\$)
1	1,850	79,500	3,340
2	1,600	63,600	3,900
3	1,400	76,320	4,460
4	1,200	74,200	5,000
5	800	63,600	6,600

A replacement analysis might look like this:

Year	1	2	3	4	5
Purchase	\$106,000	\$106,000	\$106,000	\$106,000	\$106,000
Salvage	\$79,500	\$69,500	\$76,320	\$73,000	\$70,000
Cost	\$26,500	\$36,500	\$29,680	\$33,800	\$36,000
Cumulative operating hours	1,850	3,450	4,850	6,050	6,850
Ownership cost \$/hr	\$14.32	\$10.58	\$6.12	\$5.45	\$5.26
Cumulative maintenance expense	\$3,340	\$7,240	\$11,700	\$16,700	\$23,300
Operating cost \$/hr	\$1.81	\$2.10	\$2.41	\$2.76	\$3.40
Total \$/hr	\$16.13	\$12.68	\$8.53	\$8.21	\$8.66

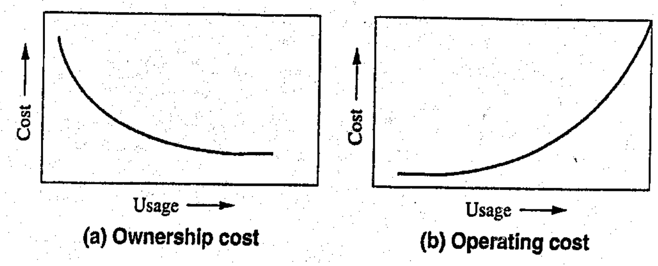


FIGURE 2.8 Effect of cumulative usage on cost.

If an owner considers only purchase price and expected salvage, the numbers argue (ownership cost $/hr) that the machine should not be traded (see Fig. 2.8a). However, if only operating cost is examined, the owner would want to trade the machine after the first year, as operating expenses are continually rising with usage (see Fig. 2.8b). A correct analysis of the situation requires that total cost be considered. So in the case of Example 2.16, the most economical service life of this machine is 4 yr, as $8.21/operating hour is the minimum total cost.

The analysis is based on *cumulative* hours. This is an important point that is often missed. If the owner chooses to keep the machine 5 yr, the effective loss is $0.45 ($8.66 − $8.21) on *every operating hour*, not just the 800 hr of the last year. When the total operating hours are large, the significance of this cumulative effect can become much greater than it would appear by simply looking at the *combined cost per hour* values.

The replacement analysis should present all the cost and timing information affecting a machine or class of machines in a usable format. The format should be such that it is easy to perform sensitivity analyses to determine the correctness of the results. As described here, the model is a cost-minimization model. With such a model, the optimum economic life of a machine is that ownership time duration that results in a minimum hourly cost.

The cash flows being studied in a replacement analysis take place at different points in time, therefore the model should consider the timing effects by use of present-value techniques. The company's cost-of-capital rate is the appropriate interest rate to use in the present-value equations.

RENT AND LEASE CONSIDERATIONS

There are three basic methods for securing a particular machine to use on a project: (1) *buy* (direct ownership), (2) *rent*, or (3) *lease*. Each method has inherent advantages and disadvantages. Ownership guarantees control of machine availability and mechanical condition, but it requires a continuing sequence of proj-

ects to pay for the machine. Additionally, ownership may force a company into using obsolete equipment. The calculations applicable for determining the cost of direct ownership have been developed.

Rental

The rental of a machine is a short-term alternative to direct equipment ownership. With a rental, a company can pick the machine that is exactly suited for the job at hand. This is particularly advantageous if the job is of short duration or if the company does not foresee a continuing need for the particular type of machine in question. Rentals are very beneficial to a company in such situations, even though the rental charges are higher than *normal* direct ownership expense. The advantage lies in the fact that direct ownership costing assumes a continuing need and utilization of the machine. If that assumption is not valid, a rental should be considered. Another important point to consider is the fact that with a rental, the company loses the tax depreciation shield of machine ownership but gains a tax deduction because rental payments are treated as an expense.

It must be remembered that rental companies only have a limited number of machines and, during the peak work season, all types are not always available. Furthermore, many specialized or custom machines cannot be rented.

Firms many times use rentals as a way to test a machine prior to a purchase decision. A rental provides the opportunity for a company to operate a specific make or model machine under actual project conditions. The profitability of the machine, based on the company's normal operating procedures, can then be evaluated before a major capital expenditure is approved to purchase the machine.

The general practice of the industry is to price rental rates for equipment on either a daily (8 hr), weekly (40 hr), or monthly (176 hr) basis. In the case of larger pieces of equipment, rentals may be available only on a monthly basis. Cost per hour usually is less for a longer-term rental (i.e., the monthly rate figured on a per hour basis would be less than the daily rate on an hourly basis).

Responsibility for repair cost is stated in the rental contract. Normally, on tractor-type equipment, the renter is responsible for all repairs. If it is a pneumatic-tired machine (on rubber), the renting company will measure tread wear and charge the renter for tire wear. In the case of cranes and shovels, the renting company usually bears the cost of normal wear and tear. The user must provide servicing of the machine while it is being used. The renter is almost always responsible for fuel and lubrieation expenses. Industry practice is that rentals are payable in advance. The renting company will require that the user furnish certificates of insurance before the machine is shipped to the job site.

Equipment cost is very sensitive to changes in use hours. Fluctuations in maintenance expenses or purchase price barely affect cost per hour. But a decrease in use hours per year can make the difference between cost-effective machine ownership and renting. The basic cost considerations that need to be

TABLE 2.4 Rental versus ownership, operating hour breakeven points.

Rental Duration	Rate ($)	Hours	Rental rate ($/hr)	Operating hour breakeven point ($26,304 /$/hr)	Operating hour breakeven point ($3,558 /$/hr)
Monthly	3,558	176	20.22	1,300	—
Weekly	1,182	40	29.55	890	120
Daily	369	8	46.13	570	77

examined when considering a possible rental can be illustrated by a simple set of circumstances. Consider a small wheel loader with an ownership cost of $10.96 per hr. Assume that the cost is based on the assumption that the machine will work 2,400 hr each year of its service life. If $10.96/hr is multiplied by 2,400 hr/yr the yearly ownership cost is found to be $26,304.

Checking with the local rental company, the construction firm receives rental quotes of $3,558 per month, $1,182 per week, and $369 per day for this size loader. By dividing with the appropriate number of hours, these rates can be expressed as hourly costs. Likewise, by dividing the calculated hourly rental rates into the construction firm's yearly ownership cost figure ($26,304) the operating hour breakeven points can be determined (see Table 2.4).

If the loader will be used for less than 1,300 hr but more than 890 hr, the construction company should consider a monthly rental instead of ownership. When the projected usage is less than 1,300 hr but more than 120 hr, a weekly rental would be appropriate. In the case of very limited usage, that is, less than 26 hr, the daily rate is optimal.

The point is that when a company rents, it pays for the equipment only when project requirements dictate a need. The company that owns a machine must continue to make the equipment payments even when the machine sits idle. When investigating a rental the critical question is usually expected *hours of usage.*

Lease

A lease is a long-term agreement for the use of an asset. It provides an alternative to direct ownership. During the lease term, the leasing company (lessor) always owns the equipment and the user (lessee) pays the owner to use the equipment. The lessor must retain ownership rights for the contract to be considered a true lease by the Internal Revenue Service. The lessor will receive lease payments in return for providing the machine. The lease payments do not have to be uniform across the lease period. The payments can be structured in the agreement to best fit the situation of the lessee or the lessor. In the lessee's case, cash flow at the beginning may be low, so the lessee wants payments that are initially low. Because of tax considerations, the lessor may agree to such a payment schedule. Lease contracts are binding legal documents, and most equipment leases are noncancellable by either party.

A lease pays for the use of a machine during the most reliable years of a machine's service life. Sometimes the advantage of a lease is that the lessor provides the equipment management and servicing. This frees the contractor from hiring mechanics and service personnel and enables the company to concentrate on the task of building.

Long-term, when used in reference to lease agreements, is a period of time that is long relative to the life of the machine in question. An agreement that is for a very short period of time, as measured against the expected machine life, is a rental. A conventional—true—lease will have one of three different end-of-lease options: (1) buy the machine at fair market value, (2) renew the lease, or (3) return the equipment to the leasing company.

As in the case of a rental, a lessee loses the tax depreciation shield of machine ownership but gains a tax deduction because lease payments are treated as an expense. The most important factor contributing to a decision to lease is reduced cost. Under specific conditions, the actual cost of a leased machine can be less than the ownership cost of a purchased machine. This is caused by the different tax treatments for owning and leasing an asset. An equipment user must make a careful examination of the cash flows associated with each option to determine which results in the lowest total cost.

Working capital is the cash that a firm has available to support its day-to-day operations. This *cash asset* is necessary to meet the payroll on Friday, to pay the electric bill, and to purchase fuel to keep the machines running. To be a viable business, working capital assets must be greater than the inflow of bills. A machine is an asset to the company, but it is not what the electric company will accept as payment for their bill.

A commonly cited advantage of leasing is that working capital is not tied up in equipment. This statement is only partly true. It is true that when a company borrows funds to purchase a machine, the lender normally requires that the company establish an equity position in the machine, a *down payment.* Additionally, the costs of delivery and initial servicing are not included in the loan and must be paid by the new owner. Corporate funds are therefore tied up in these up-front costs of a purchase. Leasing does not require these cash outflows and is often considered as 100% financing. However, most leases require an advance lease payment. Some even require security deposits and charge other up-front costs.

Still another argument is that because borrowed funds are not used, credit capacity is preserved. Leasing is often referred to as off-balance-sheet financing. A lease is considered an operating expense, not a liability, as is the case with a bank loan. With an operating lease (used when the lessee does not ultimately want to purchase the equipment), leased assets are expensed. Therefore, such assets do not appear on the balance sheet. Standards of accounting, however, require disclosure of lease obligations. It is hard to believe that *lenders* would be so naive as to not consider all of a company's fixed obligations, including both loans and leases. But the off-balance-sheet lease typically will not hurt *bonding capacity,* which is important to a company's ability to bid work.

Before entering into a contract with a construction company, most owners require that the company post a bond guaranteeing that it will complete the project. A third-party surety company secures this bond. The surety closely examines the construction company's financial position before issuing the bond. Based on the financial strength of the construction company, the surety typically restricts the total volume of work that the construction company can have under contract at any one time. This restriction is known as bonding capacity. It is the total dollar value of work under contract that a surety company will guarantee for a construction company.

Owners should make a careful examination of the advantages of a lease situation. The cash flows, which should be considered when evaluating the cost of a lease, include

1. Inflow initially of the equivalent value of the machine.
2. Outflow of the periodic lease payments.
3. Tax shielding provided by the lease payments. (This is allowed only if the agreement is a true lease. Some "lease" agreements are essentially installment sale arrangements.)
4. Loss of salvage value when the machine is returned to the lessor.

These costs all occur at different points in time, so present-value computations must be made before the costs can be summed. The total present value of the lease option should be compared to the minimum ownership costs, as determined by a time-value replacement analysis. In most lease agreements, the lessee is responsible for maintenance. If, for the lease in question, maintenance expense is the same as for the case of direct ownership, then the maintenance expense factor can be dropped from the analysis. A leased machine would exhibit the same aging and resulting reduced availability as a purchased machine.

SUMMARY

Equipment owners must carefully calculate machine ownership and operating cost. This cost is usually expressed in dollars per operating hour. The most significant cash flows affecting *ownership cost* are (1) purchase expense; (2) salvage value; (3) tax saving from depreciation; (4) major repairs and overhauls; and (5) property taxes, insurance, storage, and miscellaneous expenses. *Operating cost* is the sum of those expenses an owner experiences by working a machine on a project: (1) fuel; (2) lubricants, filters, and grease; (3) repairs; (4) tires; and (5) replacement of high-wear items. *Operator wages* are sometimes included under operating costs, but because of wage variance between jobs, the general practice is to keep operator wages as a separate cost category. Critical learning objectives include:

- An ability to calculate ownership cost.
- An ability to calculate operating cost.

- An understanding of the advantages and disadvantages associated with direct ownership, renting, and leasing machines.

These objectives are the basis for the problems that follow.

PROBLEMS

2.1 To purchase a new car it is necessary to borrow \$18,550. The bank offers a 5-yr loan at an interest rate of $4\frac{1}{4}\%$ compounded annually. If you make only one payment at the end of the loan period, repaying the principal and interest, what is the total amount that must be paid back?

a. What is the number of time periods (n) you should use in solving this problem?
b. What rate of interest (*i*), per period of time, should be used in solving this problem?
c. Is the present single amount of money (*P*) known? (Yes, No)
d. Which time value factor should be used to solve this problem?
e. What is the total amount that must be paid back?
f. How much of the total amount repaid represents interest?

2.2 To purchase a new car it is necessary to borrow \$18,550. A car dealer offers a 6-yr loan at an interest rate of 4% compounded annually. If you make only one payment at the end of the loan period, repaying the principal and interest, what is the total amount that must be paid back?

a. What is the number of time periods (*n*) you should use in solving this problem?
b. What rate of interest (*i*), per period of time, should be used in solving this problem?
c. Is the present single amount of money (*P*) known? (Yes, No)
d. Which time value factor should be used to solve this problem?
e. What is the total amount that must be paid back?
f. How much of the total amount repaid represents interest?

2.3 What amount must be invested today at an annual interest rate of $4\frac{1}{2}\%$, if you want to purchase a \$450,000 machine 4 yr in the future?

a. What is the number of time periods (*n*) you should use in solving this problem?
b. What rate of interest (*i*), per period of time, should be used in solving this problem?
c. Is the present single amount of money (*P*) known? (Yes, No)
d. Which time value factor should be used to solve this problem?
e. What is the total amount that must be invested today?

2.4 What amount must be invested today at an interest rate of $4\frac{1}{2}\%$, compounded monthly, if you want to purchase a \$450,000 machine 4 yr in the future?

a. What is the number of time periods (n) you should use in solving this problem?
b. What rate of interest (i), per period of time, should be used in solving this problem?
c. Is the present single amount of money (P) known? (Yes, No)
d. Which time value factor should be used to solve this problem?
e. What is the total amount that must be invested today?

2.5 To purchase a new truck it is necessary to borrow $18,550. The bank offers a 5-yr loan at an interest rate of $4\frac{1}{4}$% compounded monthly. You will be making monthly payments on the loan. What is the total amount that must be paid back?
a. What is the number of time periods (n) you should use in solving this problem?
b. What rate of interest (i), per period of time, should be used in solving this problem?
c. Is the present single amount of money (P) known? (Yes, No)
d. Which time value factor should be used to solve this problem?
e. What amount must be paid back each month?
f. What is the total amount that will be paid back over the life of the loan?
g. How much of the total amount repaid represents interest?

2.6 Use an interest rate equal to 7% compounded annually to solve this problem.
a. If $20,000 is borrowed for 5 yr, what total amount must be paid back?
b. How much of the total amount repaid represents interest?

2.7 A company's interest rate for acquiring outside capital is 5.5% compounded annually. If $40,000 must be borrowed for 4 yr, what is the total amount of interest that will be accrued?

2.8 A contractor is saving to purchase a $200,000 machine. How much will the company have to bank today if the interest rate is 10% and they would like to purchase the machine in 4 yr?

2.9 What amount must be invested today at an annual interest rate of $4\frac{1}{2}$%, if you want to purchase a $450,000 machine 4 yr in the future?

2.10 What amount must be invested today at an interest rate of $4\frac{1}{2}$%, compounded monthly, if you want to purchase a $450,000 machine 4 yr in the future?

2.11 What amount will a company have to place in savings today in order to purchase a $300,000 machine 5 yr in the future? The expected interest rate is 7%.

2.12 A track dozer cost $163,000 to purchase. Fuel, oil, grease, and minor maintenance are estimated to cost $32.14 per operating hour. A major engine repair costing $12,000 will probably be required after 7,200 hr of use. The expected resale price (salvage value) is 21% of the original purchase price. The machine should last 10,800 hr. How much should the owner of the machine charge per hour of use, if it is expected that the machine will operate 1,800 hr per year? The company's cost of capital rate is 7.3%.

2.13 A machine cost $245,000 to purchase. Fuel, oil, grease, and minor maintenance are estimated to cost $47.64 per operating hour. A set of tires cost $13,700 to replace, and their estimated life is 3,100 use hours. A $15,000 major repair will probably be required after 6,200 hr of use. The machine is expected to last for 9,300 hr, after which it will be sold at a price (salvage value) equal to 17% of the original purchase price. A final set of new tires will not be purchased before the sale. How much should the owner of the machine charge per hour of use, if it is expected that the machine will operate 3,100 hr per year? The company's cost of capital rate is 8%.

2.14 To purchase a new car it is necessary to borrow $18,550. The bank offers a 5-yr loan at an interest rate of $4\frac{1}{4}$% compounded annually while the car dealer offers a 6-yr loan at an interest rate of 4% compounded annually. If you make only one payment at the end of the loan period repaying the principal and interest:
a. For each case, what is the total amount that must be paid back?
b. For each case, how much of the total amount repaid represents interest?

2.15 To purchase a new truck it is necessary to borrow $18,550. The bank offers a 5-yr loan at an interest rate of $4\frac{1}{4}$% compounded monthly while the car dealer offers a 6-yr loan at an interest rate of 2% compounded monthly. If you will be making monthly payments:
a. For each case, what is the total amount that must be paid back?
b. For each case, how much of the total amount repaid represents interest?

2.16 A contractor is considering the following three alternatives:
a. Purchase a new microcomputer system for $15,000. The system is expected to last 6 yr with a salvage value of $1,000.
b. Lease a new microcomputer system for $3,000 per year, payable in advance. The system should last 6 yr.
c. Purchase a used microcomputer system for $8,200. It is expected to last 3 yr with no salvage value.

Use a common-multiple-of-lives approach. If a MARR of 8% is used, which alternative should be selected using a discounted present worth analysis? If the MARR is 12%, which alternate should be selected?

2.17 What is the largest single equipment cost?

2.18 Regardless of how much a machine is used, the owner must pay owning cost. (True : False).

2.19 A machine's owning cost includes:
a. Tires
b. Storage expenses
c. Taxes
d. General repair

2.20 A tractor with an adjusted basis (from depreciation) of $55,000 is sold for $60,000 and a new tractor purchased with a cash payment of $325,000. These are two separate transactions. What is the tax depreciation basis of the new tractor?

2.21 A tractor with an adjusted basis (from depreciation) of $65,000 is traded for a new tractor that has a fair market value of $300,000. A cash payment of $225,000 is made to complete the transaction. What is the tax depreciation basis of the new tractor?

2.22 Asphalt Pavers, Inc., purchases a loader to use at its asphalt plant. The purchase price delivered is $235,000. Tires for this machine cost $24,000. The company believes it can sell the loader after 7 yr (3,000 hr/yr) of service for $79,000. There will be no major overhauls. The company's cost of capital is 6.3%. What is the depreciation part of this machine's ownership cost? Use the time value method to calculate depreciation. ($9.236/hr)

2.23 For the machine described in Problem 2.22 what is the depreciation part of machine ownership cost? Use the AAI method of calculation.

2.24 Pushem Down clearing contractors purchases a dozer with a delivered price of $275,000. The company believes it can sell the used dozer after 4 yr (2,000 hr/yr) of service for $56,000. There will be no major overhauls. The company's cost of capital is 9.2%, and its tax rate is 33%. Property taxes, insurance, and storage will run 4%. What is the owning cost for the dozer? Use the time-value method to calculate the depreciation portion of the ownership cost. ($29.943/hr)

2.25 Earthmovers, Inc., purchases a grader to maintain haul roads. The purchase price delivered is $165,000. Tires for this machine cost $24,000. The company believes it can sell the grader after 6 yr (15,000 hr) of service for $26,000. There will be no major overhauls. The company's cost of capital is 7.3%, and its tax rate is 35%. There are no property taxes, but insurance and storage will run 3%. What is the owning cost for the grader? Use the time-value method to calculate the depreciation portion of the ownership cost.

2.26 Lifters, Inc., purchases a mobile crane. The purchase price delivered is $863,000. Tires for this machine cost $60,000. The company believes it can sell the crane after 10 yr (1,500 hr/yr) of service for $240,000. There will be no major overhauls. The company's cost of capital is 3.9%. What is the depreciation part of this machine's ownership cost? Use the time-value method to calculate depreciation.

2.27 Using the AAI method to calculate depreciation and the Problem 2.26 information, what is the depreciation part of the machine's ownership cost?

2.28 A 140-fwhp diesel-powered wheel loader will be used at an asphalt plant to move aggregate from a stockpile to the feed hoppers. The work will be steady at an efficiency equal to a 55-min hour. The engine will work at full throttle while loading the bucket (32% of the time) and a three-quarter throttle to travel and dump. Calculate the fuel consumption using the engine consumption averages and compare the result to a medium rating in Table 2.2. (4.3 gal/hr, 4.0 gal/hr)

2.29 A 60-fwhp gasoline-powered pump will be used to dewater an excavation. The work will be steady at an efficiency equal to a 60-min hour. The engine will work at half throttle. Calculate the theoretical fuel consumption.

2.30 A 260-fwhp diesel-powered wheel loader will be used to load shot rock. This loader was purchased for $330,000. The estimated salvage value at the end of 4 yr is $85,000. The company's cost of capital is 8.7%. A set of tires costs $32,000. The work efficiency will be equal to a 45-min hour. The engine will work at full throttle while loading the bucket (33% of the time) and at three-quarter throttle to travel and dump. The crankcase capacity is 10 gal and the company has a policy to change oil every 100 hr on this job. The annual cost of repairs equals 70% of the straight-line machine depreciation. Fuel cost $1.07/gal, and oil is $2.50/gal. The cost of other lubricants and filters is $0.45/hr. Tire repair is 17% of tire depreciation. The tires should give 3,000 hr of service. The loader will work 1,500 hr/yr. In this usage the estimated life for bucket teeth is 120 hr. The local price for a set of teeth is $640. What is the operating cost for the loader in this application? ($52.007/hr)

2.31 A 400-fwhp diesel-powered dozer will be used to support a scraper fleet. This dozer was purchased for $395,000. The estimated salvage value at the end of 4 yr is $105,000. The company's cost of capital is 7.6%. The work efficiency will be equal to a 50-min hour. The engine will work at full throttle while push loading the scrapers (59% of the time) and at three-quarter throttle to travel and position. The crankcase capacity is 16 gal, and the company has a policy to change oil every 150 hr. The annual cost of repairs equals 68% of the straight-line machine depreciation. Fuel cost $1.03/gal. and oil is $2.53/gal. The cost of other lubricants and filters is $0.65/hr. The dozer will work 1,800 hr/yr. In this usage, the estimated life for cutting edges is 410 hr. The local price for a set of cutting edges is $1,300. What is the operating cost for the dozer in this application?

2.32 A 265-fwhp diesel-powered wheel loader will be used to load shot rock. This loader was purchased for $365,000. The estimated salvage value at the end of 4 yr is $105,000. The company's cost of capital is 6.4%. A set of tires costs $35,000. The work will be at an efficiency equal to a 50-

min hour. The engine will work at full throttle while loading the bucket (30% of the time) and at three-quarter throttle to travel and dump. The crankcase capacity is 12 gal and the company has a policy to change oil every 150 hr on this job. The annual cost of repairs equals 65% of the straight-line machine depreciation. Fuel cost $1.15/gal and oil is $3.00/gal. The cost of other lubricants and filters is $0.65/hr. Tire repair is 20% of tire depreciation. The tires should give 4,000 hr of service. The loader will work 2,000 hr/yr. In this usage, the estimated life for bucket teeth is 110 hr. The local price for a set of teeth is $900. What is the operating cost for the loader in this application?

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WEBSITE RESOURCES

1. www.aednet.org The Associated Equipment Distributors, Inc. (AED) is an international trade association representing construction equipment distributors, manufacturers, and industry-service firms.
2. www.aem.org The Association of Equipment Manufacturers (AEM) is a trade and business development resource for companies that manufacture equipment. AEM was formed on January 1, 2002, from the consolidation of the Construction Industry Manufacturers Association (CIMA) and the Equipment Manufacturers Institute (EMI).
3. www.caterpillar.com Caterpillar Inc. is the world's largest manufacturer of construction and mining equipment.

4. www.constructionequipment.com *Construction Equipment* magazine online.
5. www.deere.com Deere and Company, "John Deere's" Construction and Forestry Equipment Division.
6. www.elaonline.com Equipment Leasing Association (ELA) is a national organization comprised of member companies within the equipment leasing and finance industry.
7. www.equipmentworld.com Equipmentworld.com is an online magazine featuring construction industry and equipment news.
8. www.goodyearotr.com The Goodyear Tire & Rubber Company off-the-road tire information.
9. www.hcmac.com Hitachi Construction Machinery Co., Ltd. is an earthmoving construction machinery manufacturer.
10. www.machinerytrader.com Machinery Trader is a marketplace for buying and selling heavy construction equipment.
11. earthmover.webmichelin.com/na_eng Michelin's tire company's construction equipment tire information site.