TABLE P6.50

Item	Machine A	Machine B
First cost	$6,500	$8,500
Service life	4 years	6 years
Estimated salvage value	$600	$1,000
Annual O&M costs	$800	$520
Change oil filter every other year	$100	None
Engine overhaul	$200 (every 3 years)	$280 (every 4 years)

pipeline to the nearest outside supply source and to provide additional propylene by truck from an outside source. The engineers also gathered the following projected cost estimates.

- Future costs for purchased propylene excluding delivery: $0.215 per lb.
- Cost of pipeline construction: $200,000 per pipeline mile.
- Estimated length of pipeline: 180 miles.
- Transportation costs by tank truck: $0.05 per lb, utilizing a common carrier.
- Pipeline operating costs: $0.005 per lb, excluding capital costs.
- Projected additional propylene needs: 180 million lb per year.
- Projected project life: 20 years.
- Estimated salvage value of the pipeline: 8% of the installed costs.

Determine the propylene cost per pound under each option if the firm's MARR is 18%. Which option is more economical?

6.52 The City of Prattsville is comparing two plans for supplying water to a newly developed subdivision:

- **Plan A** will take care of requirements for the next 15 years, and at the end of this time, the initial cost of $400,000 will have to be duplicated to meet the requirements of subsequent years. The facilities installed at dates 0 and 15 may be considered permanent. However, certain supporting equipment will have to be replaced every 30 years from the installation dates at a cost of $75,000. Operating costs are $31,000 a year for the first 15 years and $62,000 thereafter, although they are expected to increase by $1,000 a year beginning in the 21st year.
- **Plan B** will supply all requirements for water indefinitely into the future, although it will be operated only at half capacity for the first 15 years. Annual costs over this period will be $35,000 and will increase to $55,000 beginning in the 16th year. The initial cost of Plan B is $550,000. The facilities can be considered permanent, although it will be necessary to replace $150,000 worth of equipment every 30 years after the initial installation.

The city will charge the subdivision for the use of water on the basis of the equivalent annual cost. At an interest rate of 10%, determine the equivalent annual cost for each plan, and make a recommendation to the city.

Minimum-Cost Analysis

*6.53 A continuous electric current of 2,000 amps is to be transmitted from a generator to a transformer located 200 feet away. A copper conductor can be installed for $6 per pound, will have an estimated life of 25 years, and can be salvaged for $1 per pound. Power loss from the conductor will be inversely proportional to the cross-sectional area of the conductor and may be expressed as $6.516/A$ kilowatt, where A is in square inches. The cost of energy is $0.0825 per kilowatt-hour, the interest rate is 11%, and the density of copper is 555 pounds per cubic foot.

(a) Calculate the optimum cross-sectional area of the conductor.

(b) Calculate the annual equivalent total cost for the value you obtained in part (a).

(c) Graph the two individual cost factors (capital cost and power-loss cost) and the total cost as a function of the cross-sectional area A, and discuss the impact of increasing energy cost on the optimum obtained in part (a).

6.54 All industrial facilities have a network of piping that carries water or other liquids. According to a U.S. Department of Energy study[3], 16% of a typical facility's electricity costs are for its pumping systems. Suppose that you are considering a pumping facility having 10,000 ft to carry 600 gpm of water continuously to a storage tank. The general equation for estimating fractional pumping costs is

$$\text{Cost }(\$) = \frac{1}{1705}(\text{Friction Factor}) \frac{(\text{Flow in gpm})^3(\text{Pipe length in ft})}{(\text{Pipe inner diameter in inches})^5} \times \frac{(\text{Number of hours})(\$/\text{kWh})}{(\text{Combined pump and motor efficiency as a percent})}$$

where the friction factor (based on the pipe roughness), pipe diameter, and the Reynolds number can be obtained from an engineering handbook. For most applications, the value of this friction factor will be between 0.015 and 0.0225.

(a) Using clean iron and 6-inch steel pipe (schedule 40) for pumping 70°F water, an electricity cost of \$0.05/kWh, 8,760 operating hours annually, and combined pump and motor efficiency of 70%, determine the pumping cost.

(b) With the same condition, determine the pumping cost with a 10-inch pipe.

(c) Find the current price of steel and determine the optimal size of pipe, assuming that the pumping operation would last 15 years and the savage value of the pipe at 10% of the initial investment. Assume also a discount rate of 12%.

Short Case Studies

ST6.1 Absorption chillers provide cooling to buildings by using heat. This seemingly paradoxical (but highly efficient) technology is most cost-effective in large facilities with significant heat loads. Not only do absorption chillers use less energy than conventional equipment does, but they also cool buildings without the use of ozone-depleting chlorofluorocarbons (CFCs). Unlike conventional electric chillers, which use mechanical energy in a vapor compression process to provide refrigeration, absorption chillers primarily use heat energy with limited mechanical energy for pumping. Absorption chillers can be powered by natural gas, steam, or waste heat.

- The most promising markets for absorption chillers are in commercial buildings, government facilities, college campuses, hospital complexes, industrial parks, and municipalities.
- Absorption chillers generally become economically attractive when there is a source of inexpensive thermal energy at temperatures between 212°F and 392°F.
- An absorption chiller transfers thermal energy from the heat source to the heat sink through an absorbent fluid and a refrigerant. The absorption chiller accomplishes its refrigerative effect by absorbing and then releasing water vapor into and out of a lithium–bromide solution. Absorption chiller systems are classified by single-, double-, or triple-stage effects, which indicate the number of generators in the given system.
- The greater the number of stages, the higher is the overall efficiency of the system. Double-effect absorption chillers typically have a higher first cost (but a significantly lower energy cost) than single-effect chillers, resulting in a lower net present worth.

Some of the known economic benefits of the absorption chiller over the conventional mechanical chiller are as follows.[4]

[3] "Energy Tips, Reduce Pumping Costs Through Optimum Pipe Size," Office of Industrial Technologies, Energy Efficiency, and Renewable Energy, U.S. Department of Energy.

[4] *Source*: EcoGeneration Solutions™ LLC. Companies, 12615 Jones Rd., Suite 209, Houston, Texas, 77070 (http://www.cogeneration.net/Absorption_Chillers.htm).