lting engineering practice. Without it, the lessons of the past are soon st forever and have to be relearned the hard way.

A paper, "Pumps—from the Consulting Engineers View Point," was epared by Rodger Walker, P.Eng., for presentation at one of these minars. This was the means by which some of the knowledge acquired Mr. Walker came to be recorded and is now available as reference aterial within the organization of Associated Engineering Services Ltd. Now, through the medium of this publication, the information is pre- nted for the guidance of others whose work involves them in decisions ating to pumps and their application to industry.

Walker, R. 1973
Pump Selection.
Ann Arbor Science

Selection of Pumping Equipment

The procurement and installation of the most suitable pumping equipment from all the many available alternatives is a difficult proposition, made even more difficult by high pressure salesmanship from an over-developed industry. There are more than sixty manufacturing firms selling pumping equipment in the United States of America and Canada. Pump designers move extensively from company to company within the industry, with the result that the older brand names rarely retain any specific individualities of either design or workmanship. The larger, well-known companies are frequently less reliable and provide less after-sales service than the smaller and less-known companies.

The ultimate success of a pumping installation depends largely on the competency of the specification writer and the skill of the person who evaluates the quotations. The overall success of any installation is not necessarily the lowest initial cost but the lowest capital and operating cost over the economic life of the equipment, coupled with performance, reliability, and freedom from down time. Quotation evaluations should never be done in a hurry, and the final selection should not be made until complete documentation and terms of reference are on file. *Caveat emptor* (buyer beware) is particularly appropriate in this highly competitive business. Even with the best intentions on behalf of the manufacturer and his agent, the actual date of delivery is as unpredictable as the weather and is a vendor's promise to which it is almost impossible to attach any significance.

Owner's Philosophy

Moving liquids from one place to another, similar to mechanical handling, adds cost to the product but nothing to its value and should, therefore, be done as cheaply as possible.

As previously mentioned, the overall cost of pumping is not confined to the initial capital cost, but consists of

1. installed cost—amortization;
2. power or fuel costs;
3. supervision and maintenance; and
4. the cost of down time or standby equipment.

If we are to supply water to a municipality or pump sewage with a 100% reliability, standby units must be provided. Elevated water storage or sewage lift station wet well capacity may provide some buffer storage, but is usually sufficient for only a few hours. If the service is not critical and some down time can be accommodated, a less exotic pumping system may be justified, particularly if the increase in pumping costs can be written off with some tax relief.

The cost of borrowed money has an important bearing on the design of the most economical scheme. With rising inflation and higher labour costs, a pumping system designed for an economical life of twenty years or more will invariably be a better proposition if the operating cost can be kept to a minimum, even if this does mean a higher initial capital investment. If, on the other hand, borrowed capital is difficult to obtain and the economy appears to be in a tight anti-inflationary depression wherein labour costs are likely to be fairly stable, higher maintenance costs may be acceptable on a short-term basis. This approach is particularly true in the underdeveloped countries where there is an abundant amount of cheap labour, where the governments are anxious to increase employment, and where foreign capital is extremely difficult to obtain.

The Owner is responsible for the money he is authorized to spend. It is therefore important that the Owner's cash flow position is made known to the Engineer before the design is commenced. A convenient way of doing this is for the Engineer, after he has obtained his briefing, to prepare a concept report of his proposed scheme in sufficient detail to enable the Owner to understand the various implications involved and to advise the Engineer of the financing details. For example, there is not much logic in saving $20,000 or more in capital cost of a process industry at the expense of reliability if down time costs several thousand dollars per hour.

Pump Manufacturer's Philosophy

In order to remain in business, a pump manufacturer must sell equipment, and, since a pump is not regarded as a consumable item, a sale lost today is lost forever. On the other hand, a successful, conscientious pump supplier can usually look forward to a continuing business in spare parts and additional pumps when extensions to the plant are required.

Unfortunately, with our present economic system, we are frequently obliged to accept the lowest bidder. It is sometimes difficult, without specific adverse experience with a particular manufacturer's product, to justify a more expensive unit which will, in the Engineer's opinion, give a better performance pattern during its economic life. One of the ways in which the initial cost of a pumping unit, including the motor or engine drive, can be kept to a minimum is to use as high an impeller speed as possible, but the maintenance cost is increased considerably. Most pump and engine manufacturers have in the past built slow-speed units. Depending on their capacity, pumps would operate at motor synchronous speeds of 900, 1200, 1800 rpm, and with engine drives at even lower speeds. Unfortunately, one of the faults of the present economic system is that slow-speed pumps are no longer readily available, since their initial cost is higher and the competition for the lowest bid has forced them off the market. Some manufacturers have retained their old patterns and will still cast impellers and bowl assemblies as spare parts for existing pumps, but they are reluctant to market new pumps in the low-speed range. The reasons for this policy are that slow-speed pumps are not competitive compared to the higher speed pumps and that the frequency of spare-part replacement for slow-speed pumps is considerably less.

When the prices of spare impellers and bowl assemblies are compared to the initial cost of the pump, it becomes obvious that today's pump manufacturers must rely on the spare-part service for much of their business. It is the same old story of built-in obsolescence. If pumps lasted indefinitely, the majority of pump manufacturers would soon be out of business. We are frequently told that, with modern designs and with manufacturing techniques using new alloys and better materials, higher shaft speeds are perfectly satisfactory. These statements are valid only under ideal operating conditions, which are not normally encountered in municipal or industrial pumping installations. Once the machine is subjected to wear, corrosion, or erosion, the inevitable result is misalignment and vibration. The smooth, quiet-running pump becomes a veritable grinding machine accentuated by its higher rotative speed. The frequency of repairs quickly absorbs any savings in the initial cost. Unfortunately, the magnitude of these costs is rarely appreciated unless the Owner is aware of the problem and keeps accurate maintenance and operating costs against each item of equipment. One Canadian prairie town with a large number of well pumps to supply its water requirements found that it could buy new pumps from another manufacturer cheaper than it could service its existing units.

It is not the responsibility of the Engineer to try to change the entire economic climate—indeed, if he tried he would probably ruin it completely—but it is the Engineer's responsibility to understand the various situations as they develop, to advise his clientele accordingly, and get the best possible result from a poor set of circumstances.

Consulting Engineer's Philosophy

A consulting Engineer's job is to study the problem and to devise the best scheme for achieving the required result. He must consider suction and discharge conditions, pressures and capacities, power and fuel supplies, detailed pump design, and, finally, capital and operating costs. It is possible that initially four or five schemes will evolve with apparently equal merit. It is then necessary to develop each scheme in greater detail in order to resolve into one or two viable schemes before going to tender.

During the preliminary investigations, discussions should take place between the Engineer and the pump suppliers to determine what equipment is available. Estimating prices will help considerably in determining the optimum scheme, but they are of only ball-park accuracy until the final invitations to tender are issued and the quotations are received.

The Engineer must give the pump suppliers as much data and general information as possible to ensure that the final quotations are representative of the best the industry has to offer. Typical examples of data sheets are included in the Appendices. Each supplier is asked to complete the data sheet and submit it with his quotation in order that all the submissions can be evaluated on equal terms. Unfortunately, some pump and engine suppliers are reluctant to do this, and will submit the quotations on only their own standard formats. In order to present a meaningful comparison, a tabulation sheet must be prepared by the Engineer, containing all the relevant data. It is obviously in the pump supplier's interest to present his case as completely as possible. If the Engineer has to search through the pump supplier's formal quotation to uncover the information he needs, there is a possibility that some of the data will be missing and the tabulation sheet will have a few blank spaces under that supplier's name and will be an incomplete submission. The general consulting Engineer is not usually a pump or engine designer. He will have some ideas as to what he is looking for in the pumps he proposes to use, but, on the other hand, he cannot be knowledgeable of all the new techniques available to pump manufacturers. The majority of pump suppliers will welcome a general outline of the Engineer's requirements in addition to the broad parameters of design which will include the following.

—Head
—Capacity
—Available Net Positive Suction Head (*NPSH*)
—Shaft speed preferred
—System head curve parameters
—Horse power characteristics
Whether or not there are any possibilities of the pumps operating at different discharge conditions than at the design point.
—Specific speed
Any particular limitations on specific speed with respect to cavitation should be stated.
—Suction conditions, including limits of submergence, suction head, or suction lift
—Drives, electric motor, or engine.

In addition to the numerical data, reference should be made to specific design codes where they are applicable.

—*American Standard for Vertical Turbine Pumps*(1)
—*Hydraulic Institute Standards*(2)
—"Centrifugal Fire Pumps"(3)
—Chapter 20, "Fire Pumps"(4)

Having provided the pump supplier with all the parameters within which he must comply, the specific details of the pump's design should be left to him and the completed questionnaire will inform the Engineer of the quality of the equipment that is being offered.

Efficiency of energy conversion is a prime consideration in municipal installations since power is often the largest item in the cost of operation. The annual power costs of each point of efficiency can be calculated and should be made known to the suppliers in the Invitations to Tender. Witnessing the pump tests and the receipt of the certified performance curves ensures the Engineer that the pumps are capable of the required performance, but it is of little value to purchase pumps on the basis of their good efficiency characteristics if they cannot be maintained in practice. The service facilities of the successful manufacturer and his agents are of considerable interest to the Owner. Equipment manufactured overseas must be adequately serviced by a large stock of spare parts carried in this country, since transportation strikes and labour disputes frequently disrupt overseas servicing arrangements.

Number of Pumping Units Required

A three-pump system using identical electrically driven pumps each capable of supplying 50% of the maximum demand is a popular arrangement. The power supply only needs to be capable of operating two pumps at any one time. The economics of a four-pump system, each capable of 33⅓% of the maximum demand, should also be investigated.

If the power supply is subject to frequent failure and a continuous pumping operation is essential—for example, a fire pump station or a sewage lift station—then either engine-driven pumps or a standby diesel generator should be considered. If engine-driven pumps are the optimum choice, an additional unit should be installed to ensure continuity of performance. For example, a three-pump system in which each pump is capable of handling 50% of the load should be increased to a four-pump system on the basis that there will be two pumps in operation, one on standby, and one down for maintenance. If, on the other hand, a standby generator is preferred, reduced voltage starting will be required and the engine generator must be capable of supplying a starting current of at least three times the normal full load current. If sequence starting can be used whereby each pump can be started on the emergency supply in a stepwise manner, then a smaller emergency generator will suffice. Likewise, the generator necessary to supply emergency power to a four- or five-pump system could be smaller than the generator necessary for a three-pump system.

If the rate of water demand is variable and variable speed pumps are required, the use of wound rotor motors with Flomatcher controls has some advantages since the starting current for a wound rotor motor is equal to, or less than, the full load current. The engine-driven generator can be reduced to approximately a third of the capacity of the unit required to start squirrel cage induction motors of equal horsepower.

For small municipal installations, it is common practice to install pumps with dual drives. This scheme consists of an electric motor and also an engine connected through a common gear box to one pump. Unless floor space is of considerable importance, it is doubtful if this arrangement represents the best use of capital since the cost of the gear box and the clutches necessary to ensure that the two drives are independent is almost as much as another pump. One engine-driven plus one motor-driven pump is equivalent to twice the pumping capacity of the dual-drive unit and is a simpler system to control for very little extra capital cost.

In an endeavour to conserve power and to ensure that each pump is operating at its best efficiency, a "cascade system" consisting of three or more pumps of various capacities, but with the same total developed head and all capable of paralleling together, has frequently been installed. An automatic controller is provided to select the optimum combination of units to suit the water demand. Unfortunately, certain pumps in the series seem to operate for most of the time while the others are idle. For most installations, and particularly for smaller systems, it is better to have all the pumps of the same capacity. The system is more flexible to meet the water demands, maintenance is easier, and wear can be uniform; it is believed that these advantages outweigh any saving in power cost that may result from a cascade system. Larger installations, with high peak demands, may profit from a two-bank system whereby one bank of pumps will handle the normal demand and the second bank, in conjunction with first bank, will cope with the peak demands. It is possible that the second bank of pumps could be engine driven, and, in this way, peak power costs can be avoided.

To find the optimum number of pumping units requires a detailed study of power costs, system demand, maintenance, power outages, and environment. A diesel-engine–driven station may be the most economical to operate but would be unacceptable in a low-lying area surrounded by residential property or adjacent to a hospital.