crates at relatively low speeds, geared turbines should be considered, as they usually offer tremendous improvements in economy. Listed below are speeds generally considered as the lowest minimum acceptable in average applications where efficiency is not highly evaluated:

Hp rating	*Approximate minimum "direct-connected" speed, rpm*
50	1000
400	1500
1000	2000
2000	2500

Naturally, these limits will be higher whenever economy is more important.

Partial-Load Economy. Efficiency at part load may be of considerable importance. This item should be studied after fixing the desired level of efficiency. On most small turbines a single valve controls the steam flow to the total area of first-stage nozzles. At light loads, the full throttling causes considerable energy loss. By sectionalizing the first-stage nozzles and controlling each section with a separate valve, either by hand or automatically, the throttling loss reduces. The importance of decreasing this throttling loss depends on the application. In noncondensing units where the demand for exhaust steam exceeds the amount furnished by the turbine, increased efficiency has practically no value. Where throttling causes heat loss to the over-all cycle, however, as in condensing applications, the added valving has considerable value.

While hand-valve arrangements are inexpensive, they have doubtful value with rapid or frequent load swings. Operators must change the settings with every sizable load change in order to realize a gain. Automatic sectional valves are comparatively expensive for small units, not being used normally for ratings less than 500 to 600 hp. Above these ratings automatic sectional valves become increasingly important.

Cost of Steam. In making any study to determine efficiency, load factor and steam cost are of greatest importance. Load factor can usually be established with fair accuracy. Computing the cost of steam may not be as easy. Cost at the boilers is usually known. When the heat divides between power generation and process requirements, however, computing the cost becomes difficult. This is particularly true where the division of heat varies on irregular swings.

In the simplest case where all the flow for process always passes through turbines, an approximate division of 15% power and 85% process can be applied to the cost of steam at the boilers. In such cases, steam cost chargeable to the turbine may be a small percentage of the total steam cost. A careful study of this situation is recommended.

Other Factors. Factors other than turbine cost may influence an installation decision. For example, if a unit is to be installed in a location needing a long run of pipe, either inlet or exhaust, cost of the larger pipe required to handle the increased flow of a less efficient unit may outweigh the lower cost of such a unit. Or, the need for low exhaust temperature may dictate the selection of a more efficient unit.

Governing. Speed-governing systems used on mechanical-drive turbines range from simple direct-acting flyball governors, through hydraulic governing systems, to the highly accurate, long-range electrical type.

Most governor designs are arranged so that pressure regulators can be applied to control speed in response to remote signals, such as pump discharge pressure, differential pressure across feed valves, combustion requirements, temperature, etc. Through the use of regulators, turbine control is very flex-

(*Continued on page* 140)

Table II: Special Features Modify Basic Standard Designs

Feature	Purpose	Remarks
Pressure regulator	To keep pump pressure constant, or hold constant excess pressure by regulating turbine speed	Used for most pump applications particularly boiler feed pumps. Can be used to keep turbine on automatic standby service
Temperature controller	To hold constant temperature by regulating turbine speed	Used for refrigerator compressor drive control
Backpressure governor	To hold pressure in exhaust line constant by changing steam flow	Can be used on dual-drive applications where speed is held by motor
Equipment for condensing operation	To provide steam sealing on noncondensing units when operating condensing	Single-stage units are basically noncondensing, for condensing operation this feature must be added. Commonly used on units for standby service or for summertime condensing operation
Lubricating oil for driven equipment	To provide oil under pressure for bearings of pump, fan or for control device	Frequently saves adding oil pump to driven equipment
Remote speed control	To control motor-driven speed changer	Convenient, a timesaver
Preset speed control	To provide momentary contact pushbutton control for automatic speed setting	Used for washing speed and full speed on paper machine drives to save time
Tripping devices	To provide automatic or remote control of shutdown devices	Additional safeguards for emergency conditions
Solenoid inlet valve	To provide for automatic quick starting	For emergency standby units
Breakaway valve	To provide high steam flow for extra high starting torque	Used on drives for equipment with high inertia

Table III: Accessories Available For Mechanical-Drive Turbines

Accessory	Remarks
Instruments	Gages, thermometers, tachometers, barometers, etc
Base	Often furnished by manufacturer of driven equipment
Jackshaft	For belt drive
Flexible couplings	Purchase through turbine manufacturer may prove convenient
Low oil-pressure trip	Added protection against loss of oil pressure
Relief valves	Primary protection against overpressure in casing
High backpressure trip	Added protection against overpressure in casing
Oil filters, purifiers, and special coolers	Keep oil clean and cool under adverse conditions
Auxiliary oil pump	For standby and starting service
Insulation or lagging	Saves heat, improves appearance
Coupling guards	Safety guard