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Design of Agricultural Drainage Pumping Plants



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1 Purpose and Scope

1.1 This Engineering Practice sets forth principles and practices useful to engineers in the planning and design of pumping plants for drainage of agricultural land. It is not intended as complete specifications and does not include pumping plants for deep well drainage.

2 Classification of Pumping Plants

2.1 For purposes of planning and design, agricultural pumping plants are classified as:

2.1.1 Pumping plants for surface drainage. These have open sumps for collecting and temporarily storing both surface and groundwater. Ditches and adjacent lowland may be used to provide added storage away from the sump area.

2.1.2 Pumping plants for subsurface drainage. These have closed sumps for storage of groundwater only.

3 Planning of Area to be Pump Drained

3.1 The drainage system of the area served by the pumps should be planned to meet both drainage needs of the area and efficient operation of the pumps.

3.1.1 Runoff from high ground, when removable by gravity flow to a suitable outlet should be excluded from the pumped area by diversion around the area or by channeling through the area.

3.1.2 Protection of the pumped area against overflow or backwater from the outlet should be provided by perimeter dikes designed against overtopping, wave action, erosion, and instability of high water stages. Disposal of interior drainage water should be provided through the dike in conduits protected by gates that prevent backflow during high exterior water stages and permit outflow during low water stages.

3.1.3 The drainage system of the pumped area should provide:

3.1.3.1 An optimum sump water stage commensurate with the design hydraulic gradient of the drainage system.

3.1.3.2 Optimum use of undeveloped swamp or wooded lowland near or adjoining the pumping plant to supplement sump storage for reduction of the pumping rate.

3.1.3.3 Drainage channels to the pumps with ample depth and capacity to avoid excessive water drawdown and channel scour.

3.1.4 Pumping plant location should be at or near the point of lowest elevation of the pumped area and accessible to an adjacent outlet.

3.1.4.1 Site adjustments should be made as necessary to provide foundations without excessive use of piling, freedom from flooding of operating equipment, access to fuel or power supply, and protection from vandalism.

3.1.4.2 Very lowland within a pumped area can often be drained more economically and satisfactorily with a second pump rather than designing the entire system for the lowest land.

3.2 The outlet channel from the pumped area shall have capacity for the discharge and shall comply with applicable drainage laws and local codes.

4 Pumping Plant Capacity

4.1 The pumping rate should be determined from the drainage requirement, plus an allowance for seepage (when this is significant), less temporary storage.

4.1.1 The drainage requirement will vary with climate, topography, soils, land use, and types of crops. The drainage requirement may be expressed as a coefficient or quantity of water to be removed per unit of area per unit of time. Drainage coefficients are established for specific areas and crops and are available in state and some local drainage guides.

4.1.2 Pumping plant capacity for surface drainage should be based on surface drainage design coefficients. In addition to state and local guides, specific coefficients can be found in ASAE Engineering Practice EP302, Design and Construction of Surface Drainage Systems on Agricultural Lands in Humid Areas.

4.1.3 Pumping plant capacity for subsurface drainage should be based on subsurface drainage design coefficients. In addition to state and local guides, specific coefficients can be found in ASAE Engineering Practice EP260, Design and Construction of Subsurface Drains in Humid Areas.

4.2 Pumping plant capacity of some areas has been established directly from experience with existing installations and local conditions. This may provide the best basis of design for plants near such sites.

5 Pump Selection

5.1 Pump selection involves determination of type, characteristics, capacity, head, size, and number of pumps in conjunction with kind and source of power, shape and size of sump, housing, and method of plant operation. Actual selection of the drainage pump will usually be based on maximum, minimum and rated or average discharge; maximum, minimum and rated or average total head; and the type of power to be supplied.

5.2 The centrifugal pump is the most common type used in agricultural drainage. There are three kinds of centrifugal pumps; radial flow, axial flow, and mixed flow. The discharge section may be a volute (radial or mixed flow), turbine (radial or mixed flow), or a straight continuation of the suction or inlet section (axial or mixed flow).

5.2.1 Radial flow pumps operate through partial conversion of velocity head, imparted by the impeller to the water, into pressure head. The conversion is accomplished by the gradual change in cross-sectional area within the impeller casing for the volute, and in a similar manner by fixed vanes for the turbine. Radial flow pumps are commonly referred to as centrifugal pumps.

5.2.2 Axial flow pumps develop head mostly by the propelling or lifting action of the vanes on water. Axial flow pumps are commonly referred to as propeller pumps. Propeller pumps are especially suited to low head and high volume requirements of most drainage sites.

5.2.3 Mixed flow pumps, with modified blades and casing features common to both radial and axial flow pumps, apply both axial and radial thrust in moving water through the pump.

5.2.4 Figure 1 is an allocation chart useful in selecting the applicable type of pump when approximate head and discharge requirements have been determined. The crosshatched band indicates an overlap in application or choice of selection.

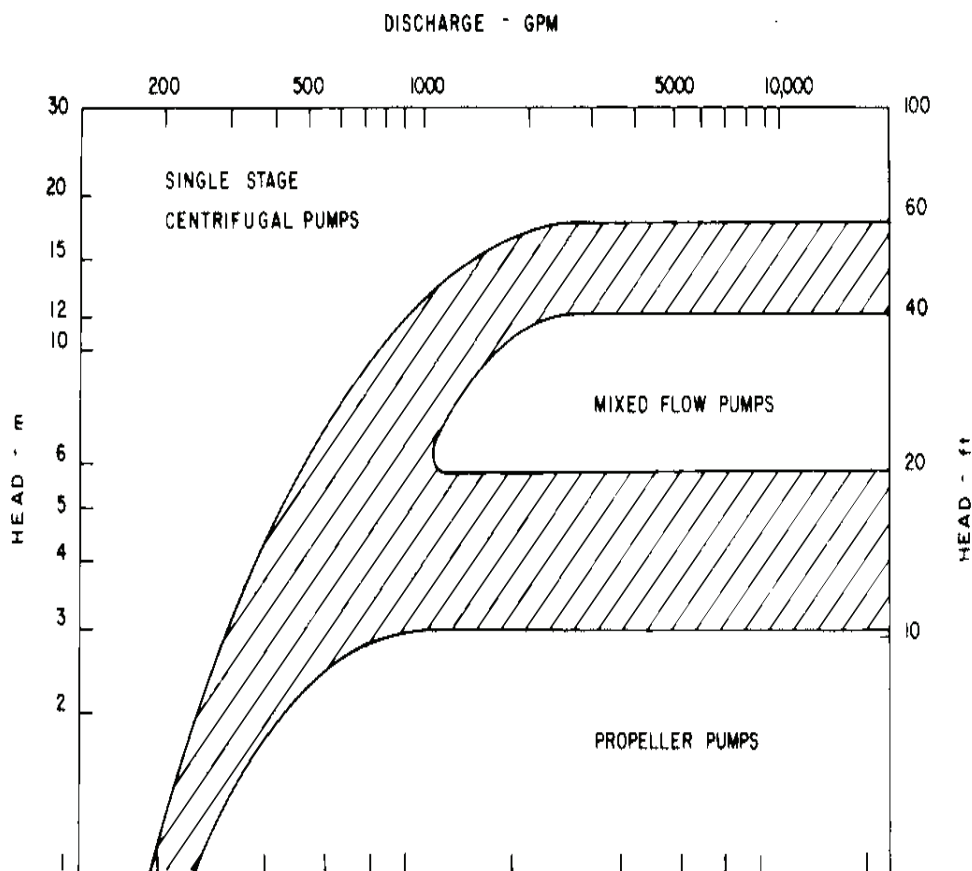


Figure 1 – Pump type selection chart. Crosshatched band shows the overlap in application or choice of selection.

5.3 Pump performance varies with head, speed, discharge, and power relationships. The effect of these factors on efficiency of the pumping operation may be obtained from pump manufacturer's performance curves or pump characteristics for each kind and size of pump made.

5.3.1 Efficiency characteristics of drainage pumps on a percentage basis are shown in Figure 2. For capacity variation (see Figure 2a), the radial flow pump covers a wide span, while for head variation (see Figure 2b), which is most important for drainage purposes, the propeller (axial flow) pump has a wider span. Generally, efficiency increases with the size of pumps. Figure 3 shows the general shape of a head-discharge curve in which abscissa and ordinate are expressed in percent of design value at maximum efficiency point and in terms of total dynamic head. The steep head-discharge curve for propeller pumps shows that this type should not be used at lower than design capacity because of increasing power requirements.

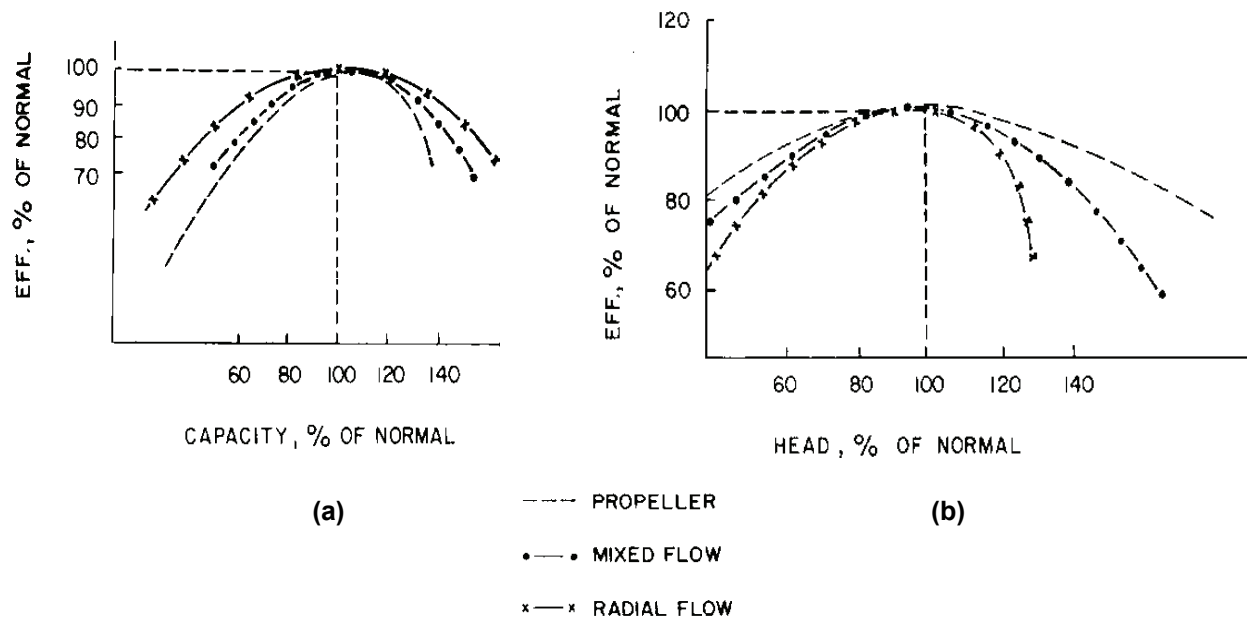


Figure 2 – Efficiency characteristics of drainage pumps

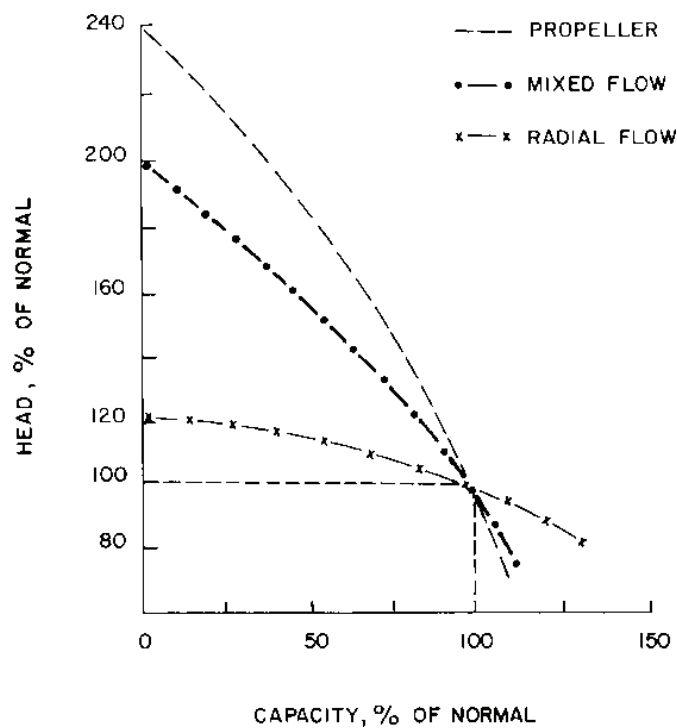


Figure 3 – Pump selection based on percent of design value at maximum efficiency point

5.3.2 Cavitation, the partial vacuum that can form in water passing through the pump impeller, causes vibration and noise from water hammer, reduction in discharge, and pump deterioration. Performance curves are useful in preventing cavitation through proper selection and operation of the pump which avoids:

5.3.2.1 Heads much higher than that at optimum efficiency of the pump.

5.3.2.2 Capacities much lower than capacity at peak efficiency of the pump.