Article 302 – Submersible Pump Sizing - Large Wells

(well sizes larger than 6" diameter having more than 50 gpm production)

Adopted by the CGA Board of Directors on October 9, 1999

BACKGROUND

Methods and practices of selecting proper pump size and horsepower are well established within the ground water industry. Detailed technical information is readily available from pump manufacturers and most California pump contractors possess the expertise necessary to select the proper pump for any specific job condition. However, Contractors are sometimes required to argue or justify their selection of a particular pump in encounters with lay persons, the courts, or specification writers.

Further problems can occur when contract specifications have been written by someone who does not have a working knowledge of the realities and dynamics of wells and groundwater systems. If an incorrect pump horsepower or model for the particular job conditions is specified, there could be premature failure of the pump or other system components if those contract specifications are followed. The Contractor may then be in a position where he is unfairly required to provide pump warranty for improper design specifications that were beyond his control.

TERMS

CAPACITY	Specific Capacity:	Gallons per Minute per foot of drawdown. A measure of the increase in production of groundwater with increasing drawdown in a well. There may not necessarily be an increase in specific capacity as the production increases.
	System Capacity Requirements:	Maximum demand during normal operation cycles.
	Well Capacity:	The maximum pumping rate the well will sustain.
FLOW	The volume of water moved over a given length of time, usually expressed in gallons per minute (gpm) or gallons per hour (gph).	
FLOW INDUCER	Generally a sleeve or shroud placed around the pump and motor such that all water entering the pump intake is forced to flow past the motor. It should be sized to provide sufficient flow past the motor for proper cooling, as per manufacturer's specifications	
FRICTION LOSS	Loss of pressure or head due to resistance to flow through pipe and fittings. Friction increases as pipe diameter decreases or flow increases. Friction loss is expressed as feet of head per 100 feet of pipe.	
HEAD	Elevation Head:	In an open discharge system, the elevation of highest water level above the well, measured in feet. In a closed pressure system, the elevation in feet from the well to the pressure tank plus the pressure setting in psig converted to feet.
	Total Discharge Head:	The total pressure or head the pump must develop. It is also referred to as total pumping head and is the sum of the depth to pumping level, the static discharge head, and the friction loss. All measurements must be converted to the same units, usually feet of head, before adding them together.
	Total Dynamic Head:	Equivalent to total pumping head plus velocity head.
	Velocity Head:	The head necessary to accelerate the liquid. Velocity head is often negligible
	TDH:	Total Dynamic Head
SETTING	The vertical distance from the top of the well to the pump	
SUBMERGENCE	The vertical distance from the water level in the well to the pump intake	
WATER LEVEL	Draw Down:	The difference between static water level and pumping level.
	Pumping Level:	The water level during pumping.
	Static Level:	The level of water in a well that is not affected by withdrawal of ground water.
WELL	Finished Diameter:	The inside diameter of the casing or column in which the pump is to be installed
	Fractures:	Cracks in bedrock plains that are intercepted during hardrock drilling. They may or may not be water bearing. Location of fractures may influence pump setting when considering motor cooling requirements.
	Well Screen:	Perforations in the well casing or liner to allow water to flow into the well column
	Well Size:	The inside diameter of the well. (see 'finished well diameter')

DISCUSSION

It is not the intent of the Standard Practice Committee to provide a complete training manual for pump selection and sizing. Adequate training is available from a variety of sources, including pump manufacturers, associations such as the California Groundwater Association, and independent contractors. This paper defines factors that should be considered during design of large water pumping systems. It is imperative to consider and incorporate these basic factors when contract specifications are written. These are standard guidelines that contractors, engineers, government agencies, and end users should be aware of.

Prior to selecting a pump to operate in a large well, accurate information about the capabilities of the well must be available. This information is far more critical for larger, higher producing wells, such as would be employed for large-scale municipal, agricultural, or commercial projects, than for smaller wells used for residential or even small community systems. A thorough production test should be performed and data analyzed to determine well capacity and efficiency. Optimum pumping levels as decided by the specific capacity of the well will determine pump setting. Once pump setting and well capacity are determined, system capacity requirements are established, and total dynamic head is calculated, a pump that will meet these criteria can be selected.

Every pump is designed and manufactured to operate within specific limits. As the pump works against increasing pressure, which is generally converted into the equivalent feet of head, the pumping capacity decreases. Conversely, as head decreases, pumping capacity increases. Graphically, pumping capacity versus the total head forms the pump's engineered curve, whose characteristics are specific for each individual pump. Within this curve are efficiency points in which the pump is designed to operate. If a pump is undersized for the pumping conditions, or operating to the left of its curve, there will be excessive head against the pump. The unit is susceptible to insufficient motor cooling and downthrust conditions against motor bearings and impeller stack and premature failure of the unit could occur.

Problems can also occur if a pump is oversized, whereby too little head is against the pump and it is operating to the right of its curve. Under these conditions, the unit may be subject to cavitation, pump and motor upthrust, and excessive motor amperage, again causing premature failure. Note that a pumping unit may be correctly sized for initial conditions, but head may change due to a rise or fall in the aquifer or to changes in the water system. In those wells with a high initial static water level where large draw down may occur, a wide range of head conditions may be encountered. In such cases, the pump must be selected that best responds to and anticipates a wider range of TDH's and rate of flow regulators may need to be included in the design of the system.

Another factor that must be considered to insure that larger submersible pumps comply with manufacturers' performance curve characteristics is submergence. Adequate pressure at the pump intake is critical to guarantee pump performance and this intake pressure is directly related to head of water above the pump. Many manufacturers will state minimum submergence required.

Submersible motors are an integral part of the pump. It must be determined if a suitable environment exists for proper operation of both. New wells should be constructed with sufficient finished diameter to allow installation of all anticipated equipment. In all wells, whether new or existing, the pump, motor, and any appurtenant devices must be physically capable of fitting into the bore hole or casing.

Submersible motors are designed to be water cooled. Sufficient flow of water over the motor must be maintained as per manufacturers' requirements for proper cooling. Pumps installed within or below the well screens or primary water bearing fractures may require flow inducers. Manufacturers' cooling requirements may be different depending on motor construction; installation instructions should be consulted.

When ambient water temperatures exceed the limits recommended by the motor manufacturer, the drive motor for the pump may need to be rated higher. The winding insulation of a larger horsepower motor would withstand more heat, while the load, or amperage, on the motor would stay essentially the same. Therefore a cushion of safety would be built into the system. Manufacturers' heat multiplier factors should be consulted and horsepower raised as necessary. Flow inducer devices should be used accordingly.

RECOMMENDATIONS

1. Proper pump selection and sizing is essential to insure efficient and reliable operation at specified head and flow rates.
2. Sufficient information should be available to accurately determine specific capacity and pumping level. If not readily available, thorough production testing of the well must be performed.
3. Adequate submergence of pump in water, according to manufacturers' recommendations, should be verified to insure operation within efficiency curve.

4. System demand requirements should be determined and, if the well capacity as determined by testing is insufficient, then modifications or adjustments to the water system may be necessary.

5. Friction losses and pressure drops from all sources should be calculated. These would include, but not be limited to, expected flow rates, pipe sizes, and total piping runs, including fittings.

6. Minimum and maximum total dynamic head should be determined. TDH would be least when the water in the well is at static level and the pressure or discharge elevation is at the lowest point. Maximum TDH would be the point where maximum drawdown could occur while the pressure or discharge elevation is the highest.

7. The pump should be sized to efficiently operate within and comply with the manufacturers' performance curve characteristics. In deep settings in wells with a high static water level, where the pump may be susceptible to upthrust condition, rate of flow regulators should be employed to keep the pump within its curve.

8. Determine velocity of water flowing past motor and if flow is insufficient to meet manufacturers' cooling requirements, install a flow inducer.

9. Verify motor horsepower will not be affected by water temperature. If pumping water at elevated temperatures, select a rated motor horsepower as necessary.

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700 R Street
Suite 200 Sacramento, CA 95811
cga@groundh2o.org
916-231-2134