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ANALYSIS OF THE SELECTION AND INSTALLATION OF A PUMP FOR AN OVERFLOW SWIMMING POOL WITH A VOLUME OF 67 CUBIC METERS

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Abstract. In the swimming pool there is a pump system that is useful for circulating water. Pumps in swimming pools can affect water quality. Dirty water will be cleaned by the filter and will be re-circulated to the swimming pool. The calculations that must be known are the volume of the swimming pool, pump power, flow rate, and the curve of the pump. In order for the selection of a swimming pool pump to be appropriate, the correct calculation must be made so that the pump can provide the best performance for a swimming pool with a volume of 67 cubic meters and is able to circulate swimming pool water 4 times during 12 working hours.

Keywords: power, pump, flowrate, swimming pool.

1. INTRODUCTION

The main objective in the analysis of the selection and installation of a pump for an overflow swimming pool with a volume of 67 cubic meters is to ensure water supply adequate at any time, both in terms of the pressure required and the debits for all outlets, equipment, and equipment.

A swimming pool is an artificial construction designed to be filled with water and used for swimming, diving or other water activities. The private swimming pool is a status symbol for the owner, because it requires a lot of space and high maintenance costs. Public swimming pools are usually part of a physical fitness center or recreational park, with other facilities including saunas, swimming sports courts (squash, tennis, etc.) and restaurants. To purify and disinfect water, chlorine is usually used. In swimming pools there is a pump that functions to circulate water so that it continues to flow and the water remains full. The swimming pool circulation systems that are commonly used are skimmer, overflow and semi-overflow systems [1][2], [3].

The Overflow System is a water circulation system that conditions the swimming pool water to overflow to certain sides or overflow to all sides of the swimming pool. The overflowing pool water then spills automatically into the Gutter Overflow (Gutter is a channel made on the edge of the pool which functions as a channel to accommodate the overflow of pool water and simultaneously directs overflow water to the Balancing Tank) [4], [5].

Figure 1. Overflow System

The way the Overflow circulation system works is that the overflow of our swimming pool water will enter the Balancing Tank through the Gutter Overflow pipe, then the water that is already in the Balancing Tank will be sucked into the Pump Then the water enters the Sand Filter After that the water that has been filtered clean will return back into the pool through the Inlet Fitting. That's the working pattern of the Overflow swimming pool water circulation system continuously. By using this circulation system, of course the cost of building a swimming pool will seem more expensive because to support this circulation system, two additional small buildings are needed, namely Gutter Overflow and Balancing Tank.

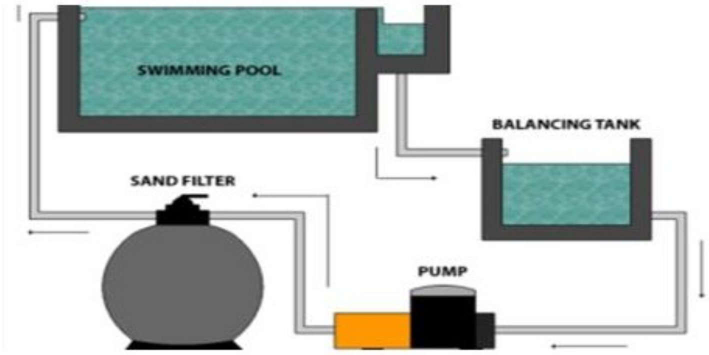


Figure 2. Overflow Swimming Pool Schematic

Centrifugal pumps are included in the type of dynamic pressure pump, where this type of pump has an impeller that functions to lift fluid from a low place to a higher place or from lower pressure to higher pressure. Power from outside is given to the shaft to rotate the impeller into the pump housing, then the fluid around the impeller will also rotate as a result of the impeller blades pushing. Due to the emergence of centrifugal force, the fluid flows from the middle of the impeller out through the channels between the impeller blades. The fluid head will increase because the fluid is accelerating. The fluid coming out of the impeller is accommodated by a volute-shaped channel around the impeller and channeled out of the pump through the nozzle, in the nozzle the fluid flow velocity is converted into pressure head [6]–[8].

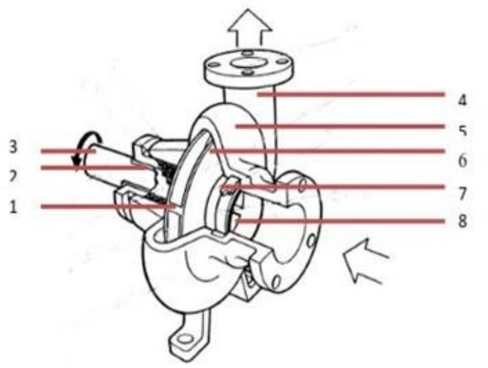


Figure 3. Centrifugal Pump

Centrifugal pump parts are:
1. Impeller blades are impellers that function as a place for liquid to pass through the impeller.
2. Packing is used to prevent and reduce fluid leakage from the pump casing associated with the shaft, usually made of Asbestos or Teflon.
3. The shaft or shaft serves to continue the torque from the drive during operation and the pedestal of the impeller and other rotating parts
4. Discharge nozzle is part of the pump that functions as a place for the pumped fluid to come out.
5. Casing is the outer part of the pump which functions as a protective element inside.
6. The impeller functions to convert the mechanical energy from the pump into velocity energy in the fluid which is pumped continuously, so that the fluid on the suction side will continuously enter to fill the void due to the displacement of the previously entered fluid.
7. Bearings function to support or hold the load from the shaft so that it can rotate. Bearings also function to smooth the rotation of the shaft and hold the shaft to keep it rotating in place, so that frictional losses can be minimized.

8. The input impeller is the part that enters the suction direction of the impeller.

The swimming pool consists of various components that help the pump circulate the water contained in it, the following is an explanation of the main components found in the swimming pool:

a. Balancing tank serves to balance the pool water. If it rains, the overflow of water that enters the pool is accommodated by this tool. If the pool water starts to recede, the water in the balancing tank will flow into the pool.

Figure 4. *Balancing Tank*

b. Gutter is located on the edge of the swimming pool. Serves to accommodate pool water spills to be channeled to the balancing tank. Then from the balancing tank it flows to the filter to be filtered

Figure 5. *Gutter*

c. Sand Filter as a filter component of dirt contained in swimming pool water. Apart from being affordable, the Sand Filter operational and maintenance system is also very easy to learn. As a filtering medium, this Sand Filter uses silica sand which has a diameter of 0.4-0.5mm. To get maximum clarity, you can use silica sand with an even smaller diameter. For information, this silica sand can also be replaced with other media such as Green Solid. Because it has better filtering quality, this media is far more expensive than silica sand.

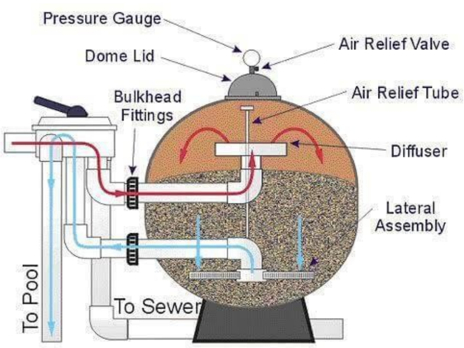


Figure 6. Sand Filter System

2. METHODS

The scheme built in the analysis of the selection and installation of pumps for overflow swimming pools is as shown in Figure 7 in below [9][10].

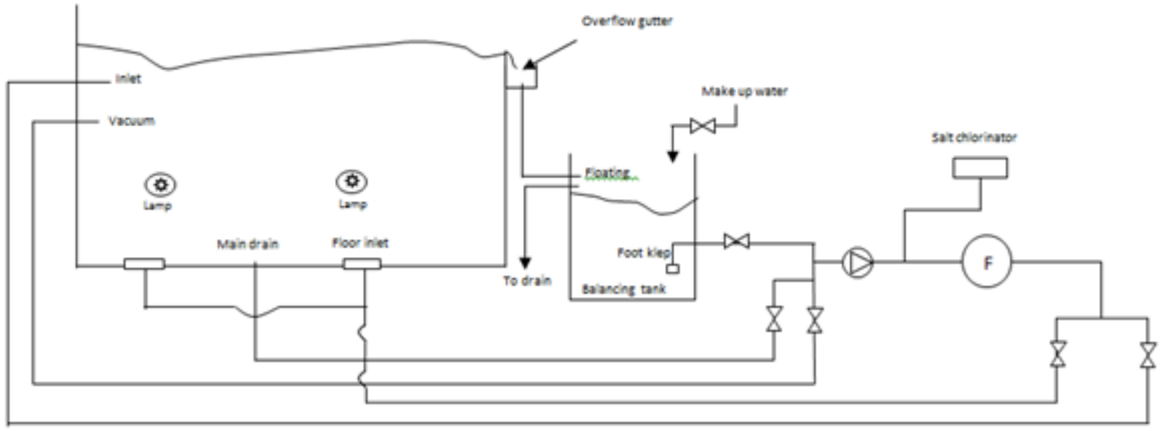


Figure 7. Overflow pool schematic

In the process of selecting a pump for a swimming pool, of course there are processes or stages that must be carried out before installing a pump, the following are things to look for [11][12]:

a. Swimming pool volume

$$V = P \times L \times T \quad (1)$$

In which:
V = Volume (m^3)
P = Swimming pool length (m)
L = Swimming pool width (m)
T = Pool depth (m)

b. Debit

$$Q = \frac{V}{W} \quad (2)$$

In which:
Q = Debit (m^3/s)
V = Flow volume (m^3)
W = Flow time (detik)

c. Input losses

$$V_s = \frac{Q}{A_s} \quad (3)$$

In which:
V = Flow rate average (m/s)
Q = Volumetric flow rate (m^3/s)
A = Cross-sectional area (m^2)

$$h_{L1} = K\frac{v_s^2}{2g} \quad (4)$$

In which:
h_{L1} = Input losses (m)
K = 1 (The discharge from the pipe into the pool)
v = Average speed of flow (m/s)
g = Earth's gravity (9,81 m/s^2)

d. Friction loss in the suction line

$$N_R = \frac{v_s . D_s . \rho}{\mu} \quad (5)$$

In which:
N_R = Reynold's number
v = Average speed of flow (m/s)
D = Inside Diameter (m)
ρ = Density (kg/m^3)
μ = DynamicViscosity ($N.s/m^2$)

$$f = \frac{64}{N_R} \quad (6)$$

In which:

f = friction factor

$$h_{L2} = f_s \frac{L.v_s^2}{D_s.2g} \quad (7)$$

In which:

h_{L2} = Friction loss in the suction line (m)

L = Channel length (m)

e. Loss of valves

$$V_d = \frac{Q}{A_d} \quad (8)$$

In which:

A = Flow area (m^2)

$$h_{L3} = f_T \frac{L_e}{D} \frac{v_d^2}{2g} \quad (9)$$

In which :

h_{L3} = Loss of valves (m)

f. ElbowLosses

$$h_{L4} = f_T \frac{L_e}{D} \frac{v_d^2}{2g} \quad (10)$$

In which:

h_{L4} = Elbow losses (m)

g. Output losses

$$h_{L5} = K \frac{v_d^2}{2g} \quad (11)$$

In which:

h_{L5} = Output losses (m)

h. Total loss due to friction

$$h_L = h_{L1} + h_{L2} + h_{L3} + h_{L4} + h_{L5} \quad (12)$$

In which:

h_L = Total loss due to friction (m)

i. Pump head

$$hA = (Z2 – Z1) + hL \quad (13)$$

In which:

hA = Pump head (m)

(Z1 – Z2) = Difference in height (Reservoir 1 dan Reservoir 2) (m)

3. RESULT AND DISCUSSION

3.1 Result

The swimming pool used is a type of overflow swimming pool, the reason for choosing this overflow swimming pool is that this type of swimming pool has an artistic element and is pleasing to the eye because all the edges of the wall are immersed in water. This overflow swimming pool also has the advantage that the dirt or leaves that are above the floating swimming pool will fall into the overflow gutter and make the swimming pool always look clean, another advantage is that someone who swims in it will not be sucked in because of the Maindrain. The type of swimming pool filter used is a type of sand filter, the advantage of using this type of sand filter is that the sand used can be cleaned again and can be reused by backwashing. This sand filter has a construction that is durable and strong compared to other filters, the sand used in this sand filter has a service life of 5-8 years. The selection of the pump used in this swimming pool is a pump that has a high discharge or flowrate, because the pump here is used to circulate swimming pool water many times, so the pump needed is a pump with a head that is not too high with a high discharge. The application of a swimming pool water circulation system is based on the clarity of the water itself, if the water is clear then the swimming pool water circulates 4 times in 12 hours for one day.

The selection of swimming pool pumps has previously gone through a valid data collection stage, so that the performance of the pump can be maximized for the swimming pool to be circulated. The following is valid data that has been obtained from the Overflow swimming pool: [13], [14]

Pool length = 12 m

Swimming pool width = 4 m
Pool height = 1.4 m
Water flows at 25^0 C
Density (ρ) = 997 kg/m^3
DynamicViscosity (μ) = 8.91 x 10^{-4} N.s/m^2
Nomonal pipe size $1\frac{1}{2}$ inch, friction factor (f_T) = 0.021
Dimension of PVC Pipe, Schedule 40 :
Nomonal pipe size $1\frac{1}{2}$ inch
Inside diameter (D) = 40.9 mm = 0.0409 m
Flow area (A) = 1.314 x 10^{-3} m^2
Channel length L = 15 m
Difference in height = 2.5 m
Ball valve fully open , Equivalent Length in pipe Diameters (L_e/D) = 0.05
90^0 Standart Elbow, Equivalent Length in pipe Diameters (L_e/D) = 30
The input from the balancing tank is sguare – edget inlet type (K) = 0,5
The discharge from the pipe into the pool (K) = 1

The next process is to perform pump calculations, namely to find pump head (h_A)

a. Swimming pool volume

$$V = P \times L \times T$$
$$= 12\ m \times 4\ m \times 1.4\ m$$
$$= 67\ m^3$$

b. Debit

$$Q = \frac{V}{W}$$
$$= \frac{67\ m^3}{10800/detik}$$
$$= 0{,}00620\ m^3/s$$

c. Input losses

$$V_s = \frac{Q}{A_s} = \frac{0{,}00620\ m^3/s}{1314 \times 10^{-3}\ m^2} = \frac{0{,}00620\ m^3/s}{1{,}314\ m^2} = 0{,}0047\ m/s$$

K = 0,5 (sguare-edget inlet type)

$$h_{L1} = K\frac{v_s^2}{2g}$$
$$= 0{,}5\frac{(0{,}0047\ m/s)^2}{2.9{,}81\ m/S^2} = 0{,}5\frac{0{,}000022\ m^2/S^2}{19{,}62\ m/S^2} = \frac{0{,}000011\ m^2/S^2}{19{,}62\ m/S^2} = 0{,}00000056\ m$$

d. Friction loss in the suction line

$$N_R = \frac{v_s.D_s.\rho}{\mu}$$
$$= \frac{(0{,}0047\ m/s)\ (0{,}0409\ m)(997\ kg/m^3)}{8{,}91 \times 10^{-4}\ Pa.s} = \frac{0{,}192}{0{,}000891}$$
$$= 215{,}48\ (Laminer)$$
$$f = \frac{64}{N_R} = \frac{64}{215{,}48} = 0{,}297$$
$$H_{L2} = f_s\frac{L.v_s^2}{D_s.2g}$$
$$= 0{,}297\ \frac{15\mathbf{m}.(0{,}0047\ m/s)^2}{0{,}0409m.2.9{,}81\ m/s^2} = \frac{9{,}84 \times 10^{-5}\ m^2/S^2}{0{,}80\ m/s^2} = 0{,}00012\ m$$

e. Valve losses

$$V^d = \frac{Q}{Ad} = \frac{0{,}00620\ m^3/s}{0{,}00131\ m^2} = 4{,}73\ m/s$$
$$h_{L3} = f_T\frac{Le}{D}\frac{v_d^2}{2g}$$
$$= 0{,}021.0.05\ \frac{(4{,}73\ m/s)^2}{2.9{,}81\ m/s^2} = 0{,}021.0.05\ \frac{22{,}372\ m^2/S^2}{19{,}62\ m/s^2}$$
$$= \frac{0.0234\ m^2/S^2}{19{,}62\ m/s^2} = 0{,}001\ m$$

f. Elbow losses

$$h_{L4} = f_T\frac{Le}{D}\frac{v_d^2}{2g}$$
$$= 0{,}021.30\ \frac{(4{,}73\ m/s)^2}{2.9{,}81\ m/s^2} = 0{,}021.30\ \frac{22{,}372\ m^2/S^2}{19{,}62\ m/s^2}$$
$$= \frac{14{,}094\ m^2/S^2}{19{,}62\ m/s^2} = 0{,}71\ m$$

There are 3 Elbow then 3 x 0,71 m = 2,13 m

g. Output losses

$$h_{L5} = K\frac{v_d^2}{2g}$$

$$= 1\ \frac{(4{,}73\ m/s)^2}{2.9{,}81\ m/s^2} = 1\ \frac{22{,}372\ m^2/s^2}{19{,}62\ m/s^2}$$

$$= \frac{22{,}372\ m^2/s^2}{19{,}62\ m/s^2} = 1{,}14\ \text{m}$$

h. Total loss due to friction

$$h_L = h_{L1} + h_{L2} + h_{L3} + h_{L4} + h_{L5}$$

$$= (0{,}00000056 + 0{,}00012 + 0{,}001 + 2{,}13 + 1{,}14)$$

$$= 3{,}27\ \text{m}$$

i. Pump Head

$$h_A = (Z_2 - Z_1) + h_L$$

$$= 2{,}5\ \text{m} + 3{,}27\ \text{m}$$

$$= 5{,}77\ \text{m} \approx 6\ \text{m}$$

The required pump head is 6 m

3.2 Discussion

The selection of a swimming pool pump is carried out using a graph of the pump, by plotting the results of the calculations that have been carried out as shown in figure 7.[13]

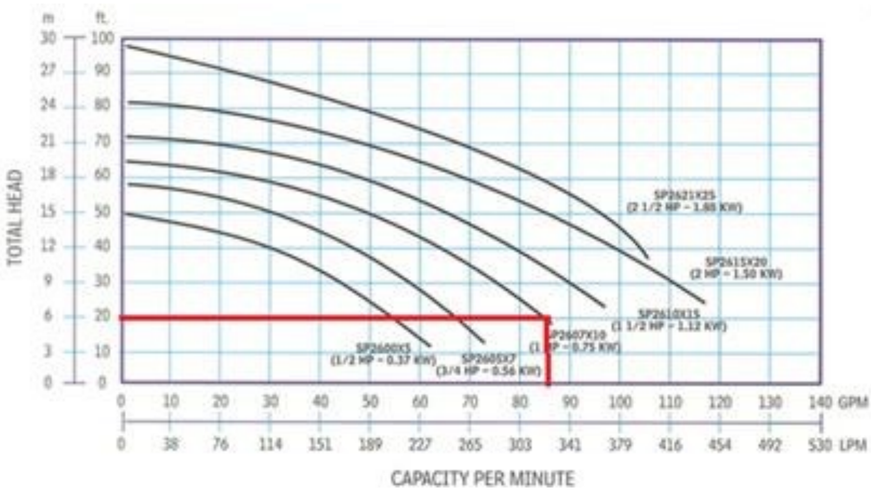
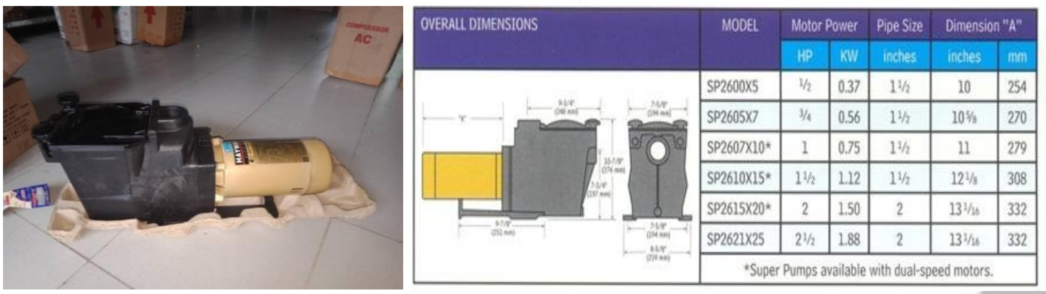


Figure 8. Pump chart

In the graph above, it can be seen that the pump head is 6 m, so a discharge of 325 liters/minute is obtained with a pump power of 1 HP. The following is a specification of a centrifugal pump that will be installed in an overflow type swimming pool.



OVERALL DIMENSIONS

MODEL	Motor Power		Pipe Size	Dimension "A"	
	HP	KW	inches	inches	mm
SP2600X5	½	0.37	1½	10	254
SP2605X7	¾	0.56	1½	10⅝	270
SP2607X10*	1	0.75	1½	11	279
SP2610X15*	1½	1.12	1½	12⅛	308
SP2615X20*	2	1.50	2	13 1/16	332
SP2621X25	2½	1.88	2	13 1/16	332

*Super Pumps available with dual-speed motors.

Figure 9. Centrifugal Pump

The pump room is located underground, the goal is to save space and does not require special soil for this part of the pump room. Before installing the pump, it is ensured that it complies with predetermined procedures, namely, has sufficient air ventilation, has special channels used to dispose of water in the event of a flood and has sufficient light to make work easier [15].

Figure 10. Pump room

The centrifugal pump used has a foundation that functions to support the pump and withstand vibrations from the pump. This foundation is longer and wider than the size of the pump holder. The pump foundation that has been made has been calculated and follows the agreed procedures. The pump foundation must be higher than the floor, which aims to avoid a short circuit from the pump in the event of a flood in the pump room.

Figure 11. Pump foundation

There are several standards for pump protection used in centrifugal pumps, namely protection against backflow. The output flow of the pump is equipped with a check valve which allows the flow to only go in one direction, in the same direction as the pump output flow. Protection against overload. Several devices such as low pressure switch, high flow switch, and overload relay on the pump motor are installed in the pump system to avoid overloading the pump. Protection for the water level switch, if there is no load, the pump will be turned off automatically. ELCB (Earth Leakage Circuit Breaker) protection aims to avoid short circuit effects that occur in swimming pools. The pump protection used is in accordance with applicable standards.

Figure 12. Pump protection

Swimming pool pump testing is carried out with the help of a measuring instrument, namely a measuring cup. Measurement of swimming pool discharge is done by calculating the flow rate using the help of a stopwatch, then the discharge flowing through the inlet of the swimming pool will be known.The test results from each inlet in the swimming pool are:
Inlet 1 swimming pool: 0.9 liter/second
Inlet 2 swimming pool: 0.9 liter/second
Inlet 3 swimming pool: 0.9 liter/second
Inlet 4 swimming pool: 1.0 liter/second
Inlet 5 swimming pool: 0.9 liter/second
Inlet 6 (waterfall) swimming pool: 0.8 liter/second

The total circulation of swimming pool water as a result of the test is 5.4 liters/second or 324 liters/minute. The time needed for 1 circulation, which is 180 minutes x 0.324 m^3/minute, is 58.32 m^3, so the pump has succeeded in circulating the swimming pool water 4 times in 12 hours.

4. CONCLUSION

Based on the test result and the discussion, it can be concluded that:

a. The pump chosen to circulate the overflow swimming pool at the hotel is a centrifugal pump with a head of 6 meters and a discharge of 325 liters/minute and a pump power of 1HP. Then the pump that has been installed is able to circulate pool water with a volume of 58.32 m3 within 3 hours.
b. In installing a swimming pool pump, it is adjusted according to the order and does not violate existing procedures.

Based on the results and conclusions of the research, some recommendations that can be submitted are as follows:

a. Maintenance carried out on swimming pool pumps must be carried out routinely or scheduled, because the operating time for swimming pool pumps is very long and is always in the on position every day to maintain water quality so that it remains clear.
b. The main components in the pump are in good condition and ready to operate. If there is noise at the pump, the pump must be turned off immediately and immediately check the cause of the noise that occurs at the pump.

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