Design of a hydropneumatic system for a building

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Abstract

This document is based on the design of a hydropneumatic system for a building consisting of 3 floors distributed in 6 apartments, located in the city of Barcelona, Anzoátegui state, in order to ensure water supply throughout the building. The document has a description of the calculations necessary for the design of the system.

Keywords: Hydropneumatic, Water Supply, Pressure, Pump

Introduction

The Hydropneumatic Systems are based on the principle of compressibility or elasticity of the air when it is subjected to pressure. Among the different water supply and distribution systems in buildings and installations, Hydropneumatic Equipment has proven to be an efficient and versatile option, with great advantages over other systems. This system avoids building elevated tanks, placing a tank system partially filled with pressurized air. This makes the hydraulic network maintain an excellent pressure, improving the operation of washing machines, filters, showers, fast filling of toilet deposits, among others. It also prevents the accumulation of particles in pipes by flow at low speeds. This system does not require tanks or hydraulic distribution network on the roofs of buildings (avoiding moisture problems due to leaks in the network) that make the facades look so bad and leaving this space free for different uses

Theoretical Framework

Hydropneumatic systems: they serve to maintain the constant pressure in the white water pipes inside a house, office or purifying plant. These systems allow the liquid to flow at the proper pressure and flow, regardless of the distance to which the equipment and devices that demand water are located.

Types of hydropneumatic systems: Pressurizer or Hydrocell, simple Hydropneumatic, multiple Hydropneumatic.

Parts that make up a hydro-pneumatic system: pressure tank, pump, electric switch, purge keys, check valve, flexible connections, stopcocks, pressure gauge, safety valve, pressure switches, drain device, compressor, filter, device for automatic control of the air / water ratio, external indicator of the levels in the pressure tank, pair to the visual indication of the air-water ratio, power board and motor control, among others.

Operating principle: Hydropneumatic systems are based on the principle of compressibility or elasticity of the air when it is subjected to pressure.

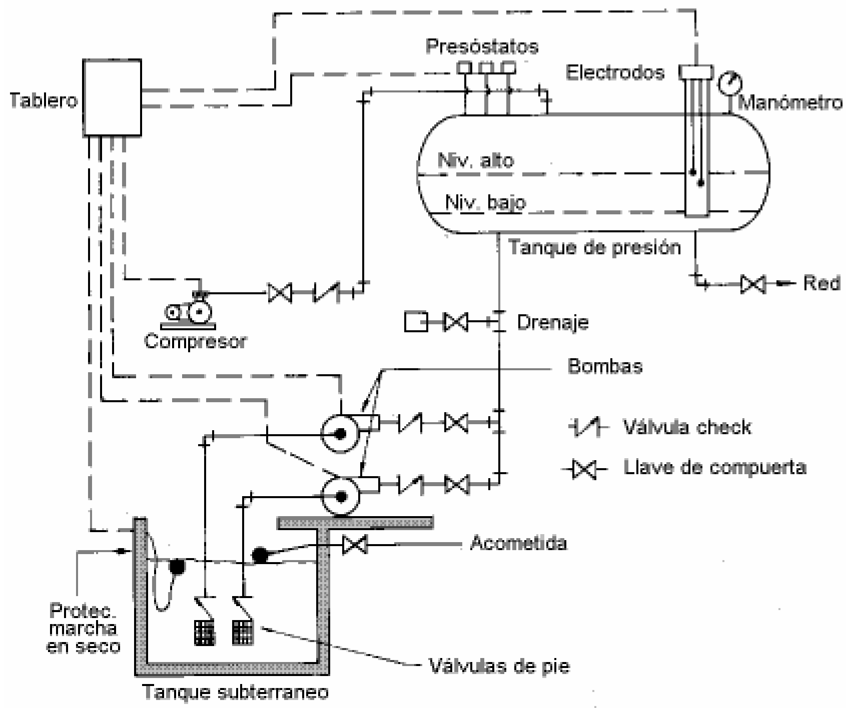

Figure 1: Diagram of a hydropneumatic system.

In the diagram represented in Figure 1; the water that is supplied from the public aqueduct or another source (service), is retained in a storage tank through a pump system, will be driven to a pressure vessel (dimensions and characteristics calculated depending on the network), and that contains variable volumes of water and air. When the water enters the container, the water level increases and compressing the air increases the pressure. When reaching a certain water level and pressure, the stop signal of the pump is produced and the tank is in the capacity to supply the network, when the pressure levels fall, to the pre-established minimum, the ignition command is activated of the pump again.

Household Hydropneumatic Systems: Hydropneumatic systems with tanks of 320 gallons or less and in buildings with 30 pieces served or less are called hydropneumatics of fifths or domestic use, their sizing methodology differs from the so-called temporary hydropneumatic, especially in the estimates of the peak flow rates of the demand since none of the other calculation methods seem to give coherent results.

Pump: For the design of the hydropneumatic system the hydraulic power necessary to satisfy the building must be calculated. The first consideration in selecting the size of the pumps, is the fact that they must be able by themselves to supply the maximum demand within the ranges of pressures and flow rates, always existing an additional pump for alternating with the (s) other (s) and to cover among all, at least 140% of the probable maximum demand.

System Life: The useful life of a hydro-pneumatic system, in this case residential and for low-rise buildings, it will depend on the maintenance program that can be given to the system, since the average life of a hydropneumatic equipment of this type exceeds ten years, if it is given adequate maintenance.

Mechanical failures that influence the operation of a hydropneumatic system: Little volume of air, compressor disconnected, air leak in the tank, defective volume control, pressure switch, water leaks in the pipe.

Description of the hydropneumatic system design: The following design is made for a 3-floors building with 6 apartments, (properly two apartments per floor), in which you want to ensure water supply throughout the building, taking as reference for calculations the most critical point of the building (the last apartment), maintaining a calculated pressure value, according to the theoretical bases taken for the design of the hydropneumatic systems. The values of diameters were assumed according to those used commercially.

Methodology

Firstly, the volumetric flow rate will be determined according to the Hunter method, which estimates the flow rate by making a sum with each one of them for each sanitary piece. After this, the calculation of speeds for each section of pipeline will be carried out. Once the velocity study has been carried out, the Bernoulli principle is applied from the outlet of the pressurized tank to the most critical point of the building. Subsequently, the approximate capacity of the pressure tank will be determined. Finally, the Bernoulli principle will be used again from the sump to the entrance of the pressurized tank.

Assumptions and Limitations

- The most critical point of the building (the last apartment) will be taken as reference for the calculations.
- The values of diameters were assumed according to those used commercially.

Results

For the design of the hydropneumatic system the following calculations were made:

1. Volumetric Flow Rate:

$$Q = 9{,}42\ \frac{L}{s} = 0{,}00942\ \frac{m^3}{s}$$

This has to be the flow rate required for the entire building to satisfy the demand.

2. Speeds:

The velocity values for the different pipe diameters of each section are the following:

Table 1: Velocity values for each diameter

Diameter (in)	Speed (m/s)	Flow rate (m^3/s)
3	2,066	0,00942
2 ½	2,974	0,00942
2	3,09	0,00628

1 ½	2,754	0,00314
1 ½	1,377	0,00157
1	3,09	0,00157
1	1,322	0,00064

3. Minimum and maximum pressure:

Applying the Bernoulli equation from the tank outlet to the most critical point of the system, the minimum pressure in the tank is obtained as a function of the losses in the entire pipeline.

$$P_1 = 15{,}1608\ m \quad (Minimum\ pressure)$$

To determine the maximum pressure a difference of 14 meters of pressure is established with reference to the minimum pressure according to theoretical bases.

$$P_{max} = 29{,}1608\ m$$

4. Pressure tank:

The size of the tank is a function of the minimum and maximum total pressure, such as the number of pump starts and stops. Taking as a criterion a number of pump starts of 4 times per hour, a multiplying factor is obtained to calculate the volume of the pressure tank.

$$V_{Tp} = 6515\ L$$

5. Pump:

With the Bernoulli equation applied before, the pump load will be obtained.

$$H_B = 16{,}894m \ \cong 17m \quad (Pump\ loading\ height)$$

With pump loading height, pump power is calculated

$$HP_{(Pump)} = 3{,}559Hp \ \cong 3\ ½\ HP \qquad (Pump\ power)$$

According to the Sulzer pump catalog; the pump to be used for this design with an H_B = 17 m and a Q = 33.91 m^3 / h (0.00942 m^3 / sec) is 3x4x8B rotating at 1775 RPM.

Conclusions and Recommendations

Hydropneumatic systems guarantee the same pressure throughout the entire pipe network.

This system is ideal for buildings due to the constant demand of flow.

The differences of minimum and maximum pressures help us determine the volume of the pressurized tank.

This system is based on turning on the pump when registering a pressure drop in the tank.

The total sum of the volumetric flow rates of the pumping units used will never be less than 140% of the probable maximum flow rate calculated in the network.

It can be said that any installation for water distribution (sanitary use, fire, irrigation, etc.) can be supplied from a hydropneumatic

It is recommended to use two pumps: one operative and the other in reserve, to prevent a possible failure of the first one.

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