US Army Corps
of Engineers
Afghanistan Engineer District

AED Design Requirements:
Hydropneumatic Tanks

Various Locations,
Afghanistan

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AED DESIGN REQUIREMENTS
FOR
HYDROPNEUMATIC TANKS
VARIOUS LOCATIONS,
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1. General

The purpose of this document is to provide requirements to Contractors for any project requiring hydro-pneumatic tank design and construction.

2. Hydropneumatic Tanks

There are several different functions that a hydropneumatic tank can perform. In a booster pump application, it can provide water to the system during periods of a no flow shutdown of the booster pump or it can provide water to replace leak loads. In a well water application, it can provide the desired volume of water required between the pump shut down pressure and the pump turn on pressure. In a sprinkler or irrigation pump application, the tank may provide a cushion to maintain necessary pressure so the jockey pump will not short cycle.

3. Type of Tanks

a) Bladder Tanks. Bladder tanks are required in a closed loop heating or chilled water HVAC system to absorb the expanding fluid and limit the pressure within a heating or cooling system. A properly sized expansion or compression tank will accommodate the expansion of the system fluid during the heating or cooling cycle without allowing the system to exceed the critical pressure limits of the system. The expansion or compression tank uses compressed air to maintain system pressures by accepting and expelling the changing volume of water as it heats and cools. Some tank designs incorporate a diaphragm or bladder to isolate the expanded water from the pressure controlling air cushion. As water is expanded, it is contained in the bladder preventing tank corrosion and water logging potentials. The pressure controlling air cushion is pre-charged at the factory and can be adjusted in the field to meet critical system requirements. This design and operation of this style of expansion tank allows the designer/specifying engineer to reduce tank sizes up to 80%. Bladder tanks have a totally replaceable bladder. This tank must be equipped with large service openings and also allow the bladder to be replaced without having to remove the tank from its mounting.

b) FXA Bladder Tanks (ASME). The FXA Series tanks are manufactured to ASME specifications. The FXA's are industries broadest line of bladder style tanks. These vessels are designed using a heavy-duty replaceable butyl bladder, and are offered in sizes ranging from 10 to 4,000 gallons, with working pressures of 125 psi (standard), 200 and 250 psi.

c) Diaphragm Tanks. The diaphragm tank has been developed to allow the systems air cushion to be separated from the systems water. No water logging of the tank can occur as the air is held between the tank wall and the outside of a bladder placed inside the tank, while the system water is contained inside the bladder. This changes the system to an air elimination system, as any air extracted from the system water is passed out of the system into the atmosphere. The diaphragm cannot be replaced if the tank fails. The advantage of this style is the initial cost. On smaller tanks the cost of replacing the bladder may exceed the cost of replacing the tank.

4. Hydropneumatic Tank Sizing

A tank can be viewed as a bag of air. The goal in sizing a tank is to make the bag of air large enough so that when the desired amount of water is put in the tank the air is not compressed to a pressure greater than system design. The first step in sizing a hydropneumatic tank is to determine the amount of water that the tank will be required to supply during any given cycle, drawdown. Drawdown is determined by the following equation.

$$D = t * (Q * 60) / 4$$

Where:

D = Drawdown (liters)
T = cycle time (min.)
Q = tank flow rate (liters/sec.)

Once the drawdown has been determined the minimum and maximum pressure of the system should be determined. The minimum pressure is the pressure where the system pumps will turn on and the maximum pressure is the shut off pressure of the pumps.

The acceptance volume is the volume of water a tank is designed to hold based on the minimum and maximum pressures. In a bladder tank, a bladder smaller than the tank size is used, the acceptance volume would be what the bladder is designed to hold. Air is contained between the tank shell and the bladder,therefore it is not possible to fill the entire tank with water. Some bladder tanks have a stated "full acceptance volume". This means that if there is a loss of air in the tank, the bladder would be able to accept full tank volume without permanent damage. The acceptance volume is determined by multiplying the tank volume by an acceptance factor. The acceptance factor is determined by the following equation.

$$F = 1 - [\,(P_f + \text{atmospheric pressure}) / (P_o + \text{atmospheric pressure})\,]$$

Where:

F = acceptance factor
P_f = minimum operating pressure (gauge pressure)
P_o = maximum operating pressure (gauge pressure)
Atm = atmospheric pressure=101 kpa

Alternatively, the tank size may be determined by dividing the drawdown by the acceptance factor.

$$V = D / F$$

Where:

V = tank volume
D = drawdown
F = acceptance factor

5. As-Builts

Upon completion of installing the hydropneumatic tank, the Contractor shall submit editable CAD format As-Built drawings. The drawing shall show the final product as it was installed in the field, with the exact dimensions, locations, materials used and any other changes made to the original drawings. Refer to Contract Sections 01335 and 01780A of the specific project for additional details.

Example 1. Hydropneumatic Tank Sizing

Select a ASME replaceable bladder type hydro-pneumatic tank for municipal well water and booster application. The tank shall provide 12.5 liters per second to prevent booster pump short cycling. The allowable cycle of the booster pump is 10 minutes and the minimum and maximum operating pressures are 30 psi (207 kpa) and 60 psi (414 kpa) .

Known:

Flow (Q)=12.5 lps
Cycle (t)=10 min
P_f=207 kpa
P_o=414 kpa
Atm = 101 kpa

Find drawdown.

D=t(Q*60)/4

D=10 min((12.5 l/s)(60sec/min))/4 = 1,875 liters

Determine acceptance factor.

F=1-[(P_f+atmospheric pressure)/(P_o+atmospheric pressure)]

F=1-[(207+101)/(414+101)=0.402

Determine tank volume.

V=D/F

V=1,875 liters/0.402=4,664 liters

Use one 4,800 liter hydropneumatic tank or two 2,400 liter hydropneumatic tanks.