UNIQUE SYSTEMS®
INCORPORATED
ONE SADDLE ROAD - CEDAR KNOLLS, NEW JERSEY 07927-1998
Phone 973-455-0440 Fax 973-455-7214

HEAT EXCHANGE INSTITUTE INCORPORATED HEI MEMBER

WATERBOX PRIMING SYSTEMS – ENGINEERING DATA

Unique Systems offers a complete line of waterbox priming systems for power plant service. Our line of standard tank-mounted systems services most main condenser requirements. We also offer custom-designed systems to meet any plant need, including priming systems for large intake/discharge circulation water piping systems and other special requirements.

TANK-MOUNTED WATERBOX PRIMING SYSTEM STANDARD ENGINEERED SYSTEMS			
MODEL #	**LRVP #**	**CAPACITY**	**MOTOR**
1.5PTM-50-FR	32-50	25 ACFM	3 HP
2PTM-110-FR	40-110	50 ACFM	5 HP
2PTM-200-FR	40-200	75 ACFM	7.5 HP
2PTM-220-FR	50-220	140 ACFM	10 HP
3PTM-300-FR	65-300	200 ACFM	15 HP
3PTM-450-FR	65-450	300 ACFM	20 HP

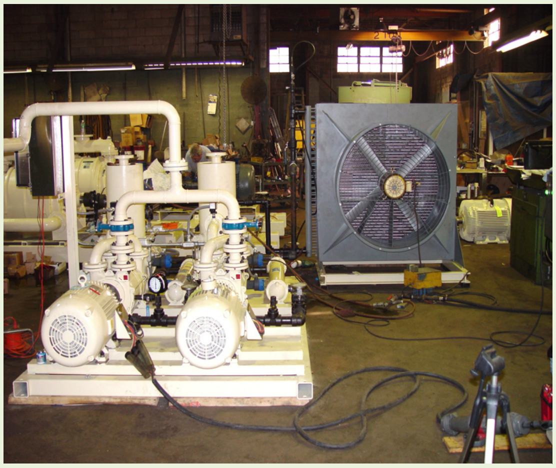
MODEL # 2PTM-200-FR WATERBOX PRIMING SYSTEM

Each system is a complete duplex package, fully piped and wired with a local control panel with PLC and operator controls. Motor starters are optional.

Custom systems are designed to meet client's specific requirements. They vary from water-cooled to air cooled units, including options for oil sealed liquid ring systems for special applications.

SIZING AND SELECTION CRITERIA

There are four primary reasons to consider the need for a priming system for the condenser and circulating water system:



MODEL # 4PSM-240-FR-AC WATERBOX PRIMING SYSTEM (BEING SET-UP FOR RUN TESTING)

- To evacuate air from the circulating water piping systems to pull water up into the waterbox before the circulation water pumps are started. This serves two purposes. One is to reduce the start-up motor horsepower demand of the circulation water pumps by reducing the discharge elevation which the pumps must push the water over to start the flow. The second is to ensure that the piping system is primed and flooded so that there is no chance of water hammer as the water falls down the discharge line back to the water source as the "siphon" is established.

- To continuously remove air that comes out of solution during normal condenser operation.

- To prevent an "air blanket" from forming inside the waterboxes which will severely inhibit the operation of automatic tube cleaning systems.

- Condenser intake & discharge piping runs, when lengthy and with several vertical changes in direction, may require priming to prevent the formation of air pockets in the pipe runs which would impede water flow to and from the main condenser.

The priming application is not always required, depending upon the actual elevations between the condenser and the cooling water source. For plants that utilize cooling towers, common practice results in the relative elevations being almost the same, obviating the need for a priming system. However, when using a natural water source (rives, oceans, lakes, etc.), the waterboxes can be substantially higher in elevation above the water source, resulting in need to evaluate the possible advantages of a priming system, due to the tendency of the waterboxes to "go negative" in pressure.

Sizing the vacuum pumps for the priming duty is a straightforward process based on time, volume, required vertical lift and cooling water temperature to correct pump capacity.

Sizing the pumps for the continuous air removal duty is a far more complex process. Air can accumulate in the waterboxes due to leaks in the piping system and from the release of air in the solution as the circulating water increases in temperature and reduces in pressure as it moves through the condenser. If this air is not removed, it can accumulate on the top of the waterboxes. This will result in the upper tube rows becoming air-bound, which not only reduces the condenser thermal efficiency but can lead to mechanical damage.

The siphon action of the circulating system can also be impaired, thus increasing the power requirements of the circulating water pumps.

It should be noted the "priming" duty and continuous removal duty are really two very different processes that result in significant design challenges for the Waterbox Vacuum System design. Based on typical operating requirements, the priming duty can easily result in the system requiring two- or four-times the capacity for air removal duty. This can lead to problems with "short cycling" of the vacuum pumps, which can cause motor overloads and other equipment problems. The designer must carefully consider the actual needs of the plant relative to the priming time vs. air removal duty to insure that the system is sized to handle both requirements without extreme over-design. It must be emphasized that over-sizing the priming pumps can lead to major operational problems which must be avoided.

ONE SADDLE ROAD - CEDAR KNOLLS, NEW JERSEY 07927-1998
Phone 973-455-0440 Fax 973-455-7214

WATERBOX PRIMING SYSTEMS – ENGINEERING DATA

Sizing the system for the continuous air removal duty is a combination of the theoretical amount of air that can be released, and an "experience factor" that is based upon actual experience as to how much air does actually come out of solution and becomes trapped in the top of the waterbox. It is generally agreed that about 10% of the theoretical air release is adequate for sizing the vacuum system.

To properly size the pumps, the hydraulic gradient across the condenser must be known. Lacking this data – which is common for new plants at the early design stages – the actual height of the waterboxes to the circulating water inlet, or the bottom of the condenser hotwell, can be taken as the vacuum (converted from the elevation in feet to inches of mercury). Given this data, we can use the known operating parameters, along with air/water saturation information, to calculate the continuous air removal duty.

Most air typically comes out of solution when cold water is moving through the condenser as it warms in the heat transfer process, since cold water holds significantly more air in solution than warm water. This usually occurs in the winter months, which can generally be used as the "worst case" for pump sizing.

Formulas for determining the ACFM capacity of the vacuum pumps for inlet & outlet waterboxes are:

Inlet Waterbox ACFM = (W1 – W2) (Va) (GPM/1,000) (0.1)
Outlet Waterbox ACFM = (W2 – W3) (Vb) (GPM/1,000) (0.1)

Where	W	:	Pounds of air per 1,000 gallons of water at the respective pressure & temperature (data commonly available)
	V	:	Volume of saturated air mixture in cubic feet at the respective pressure & temperature (data commonly available)
	GPM	:	Gallons per minute of circulating water
	0.1	:	Constant to correct for 10% empirical air release experience

When determining the actual operating pressure of the vacuum pumps, allowance must also be made for the height of the priming valve (consult the valve manufacturer based upon capacity determined above), and allowing for vacuum switch control (3" HgA differential is generally assumed). The total pressure is the negative sum (i.e. using decreasing absolute pressures applied to pump curves) of the operating pressure (the gradient or vertical lift determined above), and these three factors.

For example, assuming a gradient of 22' of H_2O (19.4" HgV or 10.6" HgA), and assuming a pressure drop of 1.5" HgA across the priming valve, the actual design operating pressure of the vacuum pumps would be 10.56 – 1.0 – 1.5 – 1.0 = 7.0 HgA.

UNIQUE SYSTEMS®
INCORPORATED
ONE SADDLE ROAD - CEDAR KNOLLS, NEW JERSEY 07927-1998
Phone 973-455-0440 Fax 973-455-7214

The actual air/vapor mixture coming from the waterboxes will expand as the inverse ratio of the pressures. Therefore, the ACFM capacity determined above must be corrected by the ratio of the pressures to determine the expanded capacity at the required operating pressure.

Note that all of these calculations are intended to give a reasonable estimate of the air which will come out of solution and should not be considered as the only factor in selecting a pump size. The design engineer should consider other factors, such as the relative capacity requirement for the priming duty, when making a final pump selection. The "empirical factor" mentioned above is given only as a general guide for preliminary sizing. In most cases, experience and knowledge of what actually works for a given set of performance criteria is required for final pump selection.

For information on our Vacuum Priming Valves, please refer to Bulletin # PVS-80023011-VPV.