

Why vacuum is maintained in condenser: an easy-to-understand guide

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A condenser is a device or unit used to condense a gaseous substance into a liquid state through cooling. In so doing, the latent heat is released by the substance and transferred to the surrounding environment. Now you may wonder what the point of maintaining vacuum in condensers is. In this article, Linquip has provided thorough information about the reason why vacuum is maintained in condensers.

Vacuum Importance in Condensing System

Not all condensers maintain vacuum but definitely those working in boiler system do. Water is used to condense steam back to liquid water in any form of boiler system, whether on board ship or in power plants. As water and steam has a volume ratio of 1:1600; that means steam is condensed to the size of 1/1600 times than before. In other words, the specific volume of water at a given pressure is many times lower than that of steam. This enormous reduction in volume creates the vacuum inside the condenser. This partial vacuum will draw in more gas to be cooled. Now to ensure proper and continuous flow of steam to condensers at all times, vacuum must be maintained externally. In other words, it is impossible to prevent the entrance of air and other non-condensable gases into the condenser. A vacuum is maintained in the condenser so that steam can easily flow and more work can be extracted from the steam in the turbine; this is the reason why vacuum is maintained in condensers. Therefore, some methods must exist to initially cause a vacuum to exist in the condenser. This necessitates the use of vacuum-producing devices to establish and help maintain condenser vacuum.



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Vacuum-producing Device Types

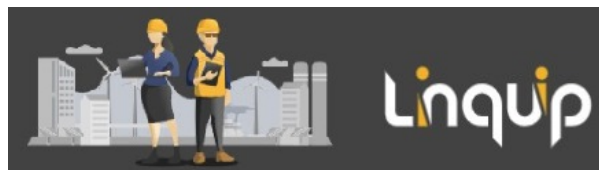
The three most common vacuum-producing devices are steam-jet air ejectors (SJAЕ), liquid ring vacuum pumps (LRVP), and a hybrid of ejector and pump.

- **Ejectors** can be operated with many different motive fluids: steam, air, organic vapor and other gases. They can handle corrosive and slugging liquids, solid and abrasive suction fluids without damage. They also have explosion-proof construction and can be installed indoors or outdoors with versatile mounting design. Furthermore, low initial cost, low maintenance cost and long life are other advantages of ejectors.

- **Liquid Ring Vacuum Pumps** are the most used vacuum-producing devices besides ejectors in industry. They are reliable with simple design involving only one rotating part, which is not subject to wear. In addition, they can handle condensible vapors or even slugs of liquid entrained in the gas stream without damage to the pump or affecting performance. They are also resistant to contaminants entering with the gas stream and include wide choice of materials available for handling most gases and seal liquids.
- **Hybrid of ejector and pump** is often used to reduce energy costs and the size of the vacuum pump. Its other advantages include operating simplicity, ability to handle corrosive vapors, available space, and the cost and availability of spare parts.

Vacuum System Application

The primary application of vacuum systems in the power generation industry is evacuating the air and other non-condensable gases from the shell side and the waterbox side of a steam surface condenser (shell and tube condenser). On the shell side, the vacuum equipment is used for two purposes: rapid evacuation of air to reduce condenser pressure before steam turbine starts, the “hogging mode,” or for continuous removal of air and associated water vapor from the main condenser when the steam turbine is in operation, the “holding mode.” The elimination of air and other non-condensable gases from the condenser shell side is necessary for appropriate heat transfer from steam to cooling water in the condenser and, consequently, to maintain high vacuum in the condenser. This increases the amount of energy extracted from the steam exhausted from the steam turbine and increases the plant’s energy production. Without a vacuum system, air and other non-condensable gases would severely reduce the heat transfer in the condenser, and the plant would require a condenser with significantly more surface area for the same thermal load. Because of this, vacuum system must exist in condensers.



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Although the working pressure of a condenser do have many advantages including faster condensation, better heat exchange, avoid air to get dissolved in water and increased overall efficiency of the unit, there is a limit to which it is feasible and when it starts to make more trouble than it solves. Generally, maintaining perfect sealing condition in a condenser as the pressure reduces below one atmosphere is a hard goal to accomplish. This increase on the cost and maintenance requirement makes it ineffective in long run. Furthermore, as we reduce the pressure; the steam starts to condense at lower and lower temperature. As the temperature of condensing steam decreases with decrease in pressure, different problems emerge to maintain the same heat exchange between the medium. Ideally, the greater the temperature difference between the two medium, the better is the heat exchange efficiency of the condenser. Similarly, if we remove the vacuum from the system it not only increases the amount of heat energy lost unused; but also causes a rapid drop in PH of the boiler water which will lead to sudden drop in system efficiency in short run and complete damage of the turbine assembly in long run. So a condenser must never be run without vacuum unless it is safe.

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So, this is all you need to know about maintaining vacuum in condensers. If you enjoyed your time in Linquip and want to share your experience with others, feel free to leave it in the comment section. We will be more than glad to have your viewpoint on the article. If you need any assistance with similar subjects, do not hesitate to sign up on our website where our experts are ready to solve your issue.