Vacuum Condenser Drainage – Proper Design & Installation Guide

1. Vacuum Condenser Drainage: Application Overview

Throughout the industry condensers are in operation servicing steam ejector vacuum systems of all sizes and ranges. Be it combined cycle, traditional thermal coal fired or oil fired power plants or renewable energy plants such as geothermal and solar plants, steam ejector vacuum systems are in service over a wide spread number of facilities all over the world. With time tested reliability and performance these vacuum systems are well understood and valued for ease of operation and thermal efficiency. However, one area that is often overlooked is the vacuum condenser drainage system. This guide will address the challenges posed in proper design of vacuum condensate drainage and offer guidelines to help reduce problems typical at plant start-up and during normal operation.

A key component in the proper design of the vacuum drainage system is the condensate drainer. The condensate drainer can take the form of a loop seal or mechanical valve drainer but the function is always the same: allowing the vacuum condenser to drain while isolating it from lower absolute pressures of the main condenser hotwell where the vacuum condenser typically drains.

2. Typical Drainage Challenges

During normal operation the vacuum condenser drainer is required to work smoothly and continuously allowing for long-term drainage of steam condensation. In the natural course of plant operation the vacuum system must respond to varying plant loads by utilizing more or less motive ejector steam in order to accommodate the air evacuation service required. As these changes occur vacuum condensate flow rates also vary and these variations can be wide; especially in combined 200% condenser systems. Such wide fluctuations in condensate flow require a condenser drainer that is properly sized in order to prevent condensate back-up in the vacuum condenser. In order to prevent condensate back-up the drainer orifice must be sized properly for maximum condensate flow rate and corresponding pressure differential available.

3. Selecting the Drainer Type Best Suited

Two options available for condenser drainage are drain loops and mechanical drainers.

Drain Loops, also called barometric legs, or loop seals, are an easy and economical option for drainage under vacuum. They are typically recommended for inter-condenser applications; however, consideration must be given to the location of the condenser drain (elevation) with respect to the condenser hotwell. If there is not enough elevation, a drain loop cannot be properly designed and installed. Parts (piping) and installation are usually done at the site for drain loops.

Steam jet air ejector systems for power plant air removal applications typically consist of a two-stage ejector system with inter- and after-condensers. The pressure of the water that condenses in the condensers is essentially at the pressure of the ejector's discharge nozzle, which, for the first stage ejector, would be under vacuum. In order to drain the condensables from the inter-condenser back to the hotwell for most power plant applications, you must calculate a barometric leg for the drain loop for the water that goes back to the hotwell. This "leg" of piping must overcome the pressure difference. The difference in the elevation between the intercondenser drain and hotwell must be such that the static head of the water in the barometric leg is greater than the pressure difference. For example, if the intercondenser is operating at 6"HgA (23.92"HgV), the barometric loop should be at least 84" (7') below the connection on the main condenser hotwell (assuming a barometric pressure of 29.92"Hg). This includes a foot or so to allow for some hydraulic loss in the barometric leg and the vent pipe. Horizontal drain leg runs are not recommended because they are susceptible to gas pockets and/or other drainage problems. Reference attached diagram for details.

Mechanical drainers are used to allow condensate to pass through, without allowing any gas through. They are usually of the ball-float type for condenser drainage. As soon as condensate reaches the drainer, the float rises and the lever mechanism opens the main valve. Condensate continues to flow through the main valve. When the liquid level drops, the float drops and closes the main valve. At all times, the main valve remains below the water level, which ensures that air or gas cannot be passed.

Ball float drainers are able to handle heavy or light condensate loads equally well and are not disturbed by wide and sudden fluctuations of pressures. They are a good choice for draining both batch and continuous process plant. Condensate is removed as soon as it is formed.

4. The Right Approach To Proper Drainage and Installation

To ensure proper drain line sizing the designer must consider the combined motive steam load to drive the jet plus the water vapor load carried over from the main condenser or gland seal. For twin elements the jet load must be doubled to account for the increased load when both elements are operating. Drain line velocities should be kept below 1 foot per second by increasing the line size to obtain a 1foot per second drain line velocity.

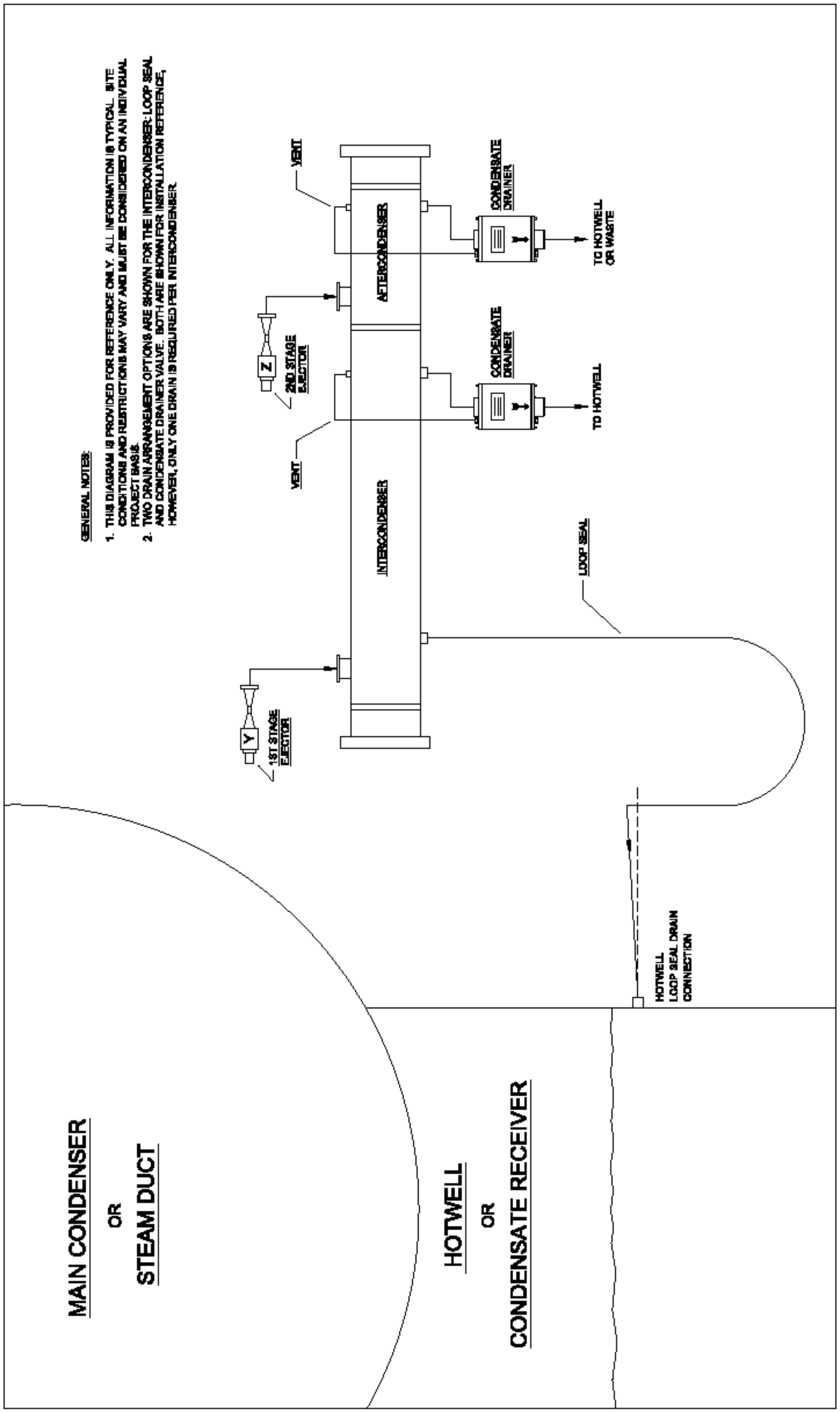
Drain lines should be vertical in direction and long horizontal pipe runs with excessive elbows and fittings should be avoided. Inter Condenser drains shall be vertical in nature draining directly into the drain control equipment or loop seal. After condenser drains shall drain to the main condenser hotwell.
Drainers shall be located a minimum of 26" directly below the air ejector condenser. Piping from the drainer to the main condenser shall be sloped downward to facilitate drainage.

Drainers shall be vented to the inter condenser to stabilize the drainer vacuum at the inter condenser working pressure. A bypass line around the drainer is sometimes required to equalize the drainer pressure to the inter condenser working pressure. After condenser drainers shall be vented back to atmosphere or the after condenser.

See the attached diagram for a typical arrangement.

<u>General Notes</u>:

1. This diagram is provided for reference only. Site conditions and restrictions may vary and must be considered on an individual project basis.
2. Two drain arrangement options are shown for the intercondenser: loop seal and condensate drainer valve. Both are shown for installation reference; however, only one drain is required per intercondenser.



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