TechData Sheet

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Pros and Cons of Returning Steam Condensate to the Boiler

Money spent on energy bills can be saved by returning condensate to the boiler. Research has shown that many Navy and Marine steam systems return only a small percentage of condensate to the boilers. Although condensate does not have the high energy content of steam, it has more energy than makeup water from the base fresh water supply. By returning condensate to the boiler rather than dumping it, the energy used to raise the temperature of the fresh makeup water to the temperature of the condensate can be saved. During a 1991 investigation by the Naval Civil Engineering Laboratory (NCEL), it was discovered that three Marine Corps bases that used 70 to 80 percent of their steam for heating, returned only 20 to 55 percent of their condensate. Bases that have clean steam requirements for shipboard use or utilize industrial processes that result in lost condensate may not be able to use this process. All other bases, however, should analyze their steam systems to determine if returning condensate to the boiler would be economical.

The components required to return condensate to the boiler are: steam traps (probably installed if the system is already in operation), piping, a condensate tank, and a pump. If steam traps exist, it would be beneficial to ensure that the proper types are installed and operating properly (see TechData Sheet 2037-E&U, "Want to Know About Steam Traps??" dated March 1997 for more steam trap information). As an example, for unit heaters using constant pressure steam, it is recommended that inverted bucket traps be installed. If the steam pressure is not constant, it is recommended that float and thermostatic traps be installed. Steam traps should be tested from once a year to once a month, depending on the application, to maximize the life of the traps and to ensure that the condensate return system is always providing the maximum performance. Contact the trap manufacturer for the testing schedule for a specific application. A steam trap that has failed open can waste from $3,000 to $50,000 per year depending on the size of the trap, and assuming 100 psi and a steam cost of $5.00 per 1,000 pounds. A trap that has failed closed may cause damage from water hammer in the equipment installed in the steam distribution system. Also, due to the steam flow area becoming waterlogged, heat transfer is less efficient which causes the boiler to work harder to meet the required heat demand.

There are four different types of condensate return systems. See Figure 1 for examples of the following:

1. Dry open
2. Wet open
3. Dry closed
4. Wet closed

In wet systems, the return pipe is below the liquid level of the downstream receiver and therefore contains only liquid, no flash vapor. In a dry system, the return pipe is above the liquid level of the downstream receiver and therefore contains both flash vapor and liquid. Flash vapor is formed when the pressure of saturated fluid is decreased causing some of the fluid to flash to steam. Since flash vapor occupies a much larger volume than that occupied by the fluid, the piping for these systems is sized by the volume of the vapor. In an open system, the condensate return is vented to the atmosphere. A closed system is not vented to the atmosphere and therefore can be either above or below atmospheric pressure. Because of these differences, piping size will vary for each system. How to size condensate piping is beyond the scope of this TechData Sheet, but further information is contained in the ASHRAE Handbook, 1997 Fundamentals, Chapter 33.

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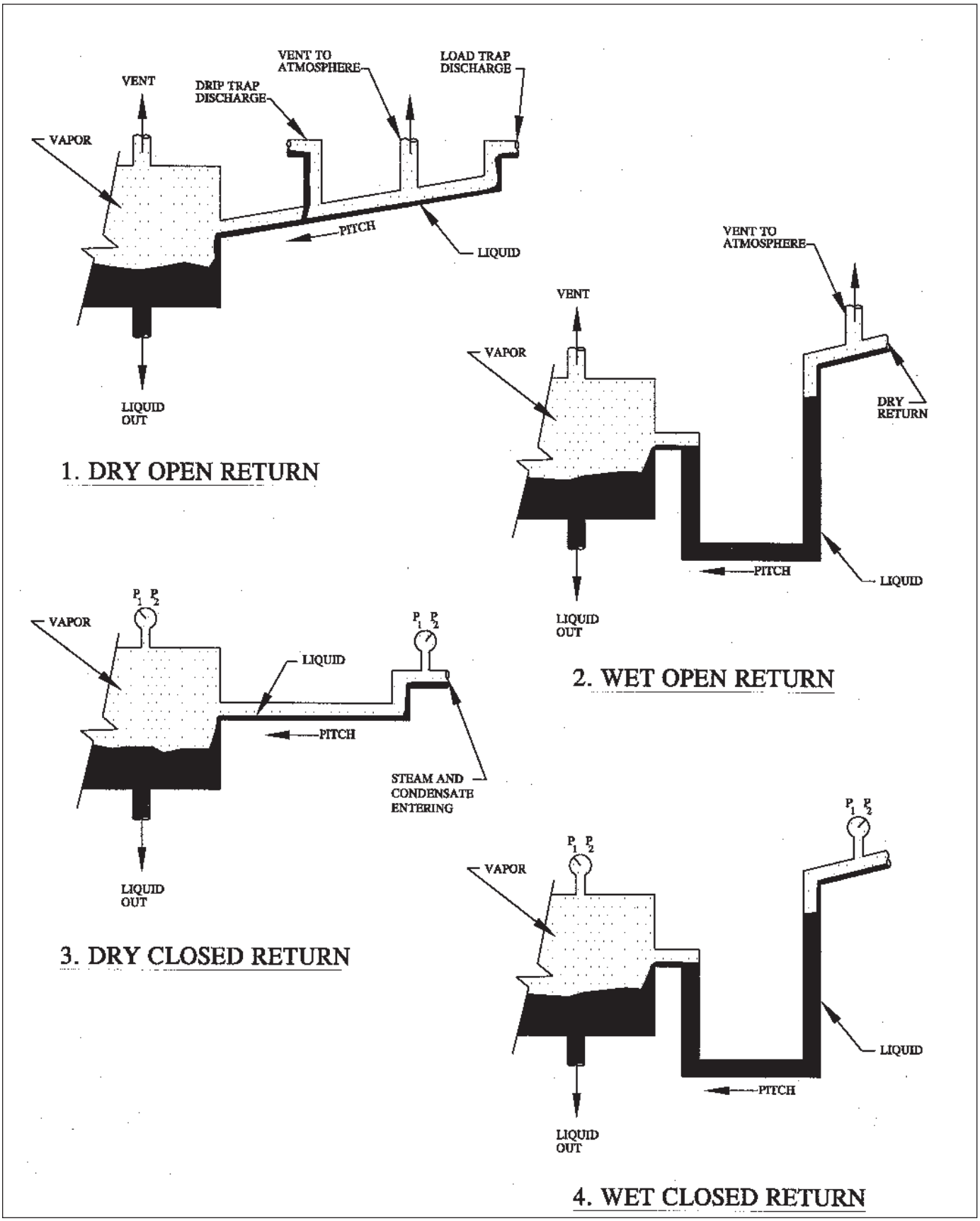

Figure 1. Types of condensate return systems.

If a steam system has a high pressure and a low pressure side, it may be desirable to add a flash tank which collects the condensate on the high pressure side of the system and lowers the pressure of the liquid, thus causing the condensate to flash to steam. This low pressure steam can then be added to the low pressure side of the system to save energy.

In addition to the potential savings due to a reduction in energy use that could be realized by returning condensate to the boiler, savings could also be achieved by:

- Reducing the amount of the makeup water which must be purchased (this amount may be negligible, depending on the geographical location).
- Eliminating the cost of treating fresh makeup water (this amount may be negligible).
- Eliminating disposal or environmental costs associated with disposing of the condensate.

To obtain an accurate estimate of the savings that may be achieved by returning the condensate to the boilers, these figures must be compared to the cost of new equipment (as explained) and increased maintenance. The best alternative is the one with the lowest life-cycle cost.

Maintenance costs should not increase dramatically if proper maintenance has been performed. Condensate return lines are susceptible to damage due to carbonic acid formed from CO_2 and corrosion due to oxygen in the system. These problems can be reduced by maintaining proper boiler chemistry to minimize the CO_2 in the steam and condensate and performing required maintenance on the rest of the system in a timely manner to reduce leaks where oxygen may be getting into the system.

To illustrate the cost savings from returning condensate to the boiler, consider this typical building, approximately 150,000 square feet:

Average annual steam use:
4,325,000 lb/yr

Average annual fuel use:
6,750 MBtu/yr=6,750 X 10^6 Btu/yr

Average annual fuel bill:
$29,700/yr

Cost per MBtu of fuel:
$4.40/MBtu

Assume that 80 percent of the condensate can be returned,
or
0.8 x 4,325,000 lb/yr = 3,460,000 lb/yr

Assume that the condensate is returned at atmospheric pressure and 190°F, and the makeup water is 55°F and at atmospheric pressure.

Since it requires approximately 1 Btu to raise 1 pound of water 1°F, it requires approximately 135 Btu to heat 1 pound of water from 55°F to 190°F.

Assume the boiler is 70 percent efficient and it takes 135 Btu/lb ÷ 0.7 = 193 Btu of fuel to raise the temperature of the makeup water to the temperature of the condensate.

If 80 percent of the condensate is returned, the total savings are:

(193 Btu Fuel/lb condensate) x (3,460,000 lb condensate/yr)
x ($4.40/Mbtu) ¸ (1,000,000) = $2,938/yr

These savings compute to more than 10 percent of the annual fuel bill.

A condensate tank and two pumps will cost approximately $4,500.

Assuming a 1-horsepower pump, electricity costs $0.10/kWh, and the pump runs 4,000 hrs/yr:

1-hp pump = 0.746 kW
Cost to run pump for 1 year:
(0.746 kW)($0.10/kWh)(4,000 hrs) = $298/yr

Total annual savings = $2,938/yr - $298/yr = $2,640/yr
The simple payback would then be ($4,500)/($2,640/yr)
= 1.7 yrs.

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