BEST PRACTICE NO. 65

INVENO ENGINEERING LLC

» STEAM BALANCING - FIRST STEP IN STEAM SYSTEM OPTI MIZATION

1. WHAT IS STEAM BALANCING?

The steam balance is the most efficient method of gaining knowledge of all aspects of the steam system, such as steam generation, distribution, end users, and condensate recovery systems. The steam balance is always the first step in any steam system management program.

The valuable knowledge gained from developing or updating a steam balance leads to setting a road map to use the steam system in the most efficient way. Every plant needs to achieve the highest steam thermal cycle efficiency possible, and the steam balance provides the information to achieve this goal. The perfect steam balance system has the end users receiving the correct volume of energy at the correct steam pressure/temperature with the proper steam quality. The perfect steam balance has no energy losses from steam leakage, excessive low pressure steam venting, flash steam, condensate, etc. Establishing the correct steam balance can be very challenging because of all the different dynamics in a steam system, such as modulating steam loads, variable production times, unaccountable losses, turbine operation, etc.

The consumers, or end users, of the steam demand the correct quantity and 100% steam quality at a given specific pressure/temperature, and it is up to the plant to manage the steam balance to meet the end users' requirements. The end users' steam demands and steam quantity constantly vary, so achieving a high steam system thermal cycle efficiency requires plants to have a well-documented steam balance to meet the production requirements.

A high percentage of the time, knowledge of the steam system gets segmented. The boiler plant personnel know the boiler plant operation well, and process personnel understand the process steam operation. Meanwhile, most of the time, the steam distribution and condensate system are left in limbo and not attended to by anyone. Often, the condensate system is omitted from the total steam system balance, even though it accounts for 16% of the overall energy in the steam vapor. The flash steam is a critical part of the steam balance, so the flash steam should be recovered by some means to ensure steam thermal cycle efficiency.

2. ACCOMPLISHING A STEAM BALANCE

It is impossible to optimize a steam and condensate system without a steam balance, which requires a complete understanding of the system. The easiest and best method to deliver that understanding is to create a simple balance flow diagram.
The steam balance flow diagram can be accomplished in many different ways, such as a fully devolved document completed in Aspen software to a simple flow diagram completed with Microsoft Visio. The key point is to have a steam balance document for plant personnel.

3. END RESULTS OF A STEAM BALANCE

Implementing a perfect steam balance between steam generation, distribution, end user requirements, and condensate recovery can be an extremely challenging goal in any industrial steam plant operation. An industrial plant can have a number of different steam-generating sources and a multitude of end users with varying steam pressure and steam flow demands. The steam turbine operation for electrical generation or drive units play an important part of the balance, and the steam pressure letdown valves (pressure-reducing valves) operation needs to be minimize to ensure maximum steam flow to the steam turbine operation. Four types of condensate recovery systems are added into the balance, making the system dynamics even more complex. Today, to meet production requirements, plants are continuing to update and make process changes that will affect the steam balance. Therefore, steam balancing is a continuous program, not a one-time venture.

The steam balance will eliminate the waste of unusable low-pressure steam being vented to the atmosphere by balancing the steam flow to the end users (steam turbines, heat exchangers, reboilers, etc.), then discharging the condensate/flash steam to the steam cascade systems to successfully end the steam process with the correct amount of low-pressure steam. If this is not accomplished, then the low-pressure steam is thermocompressed to medium steam pressure grids until balance is achieved in the system.

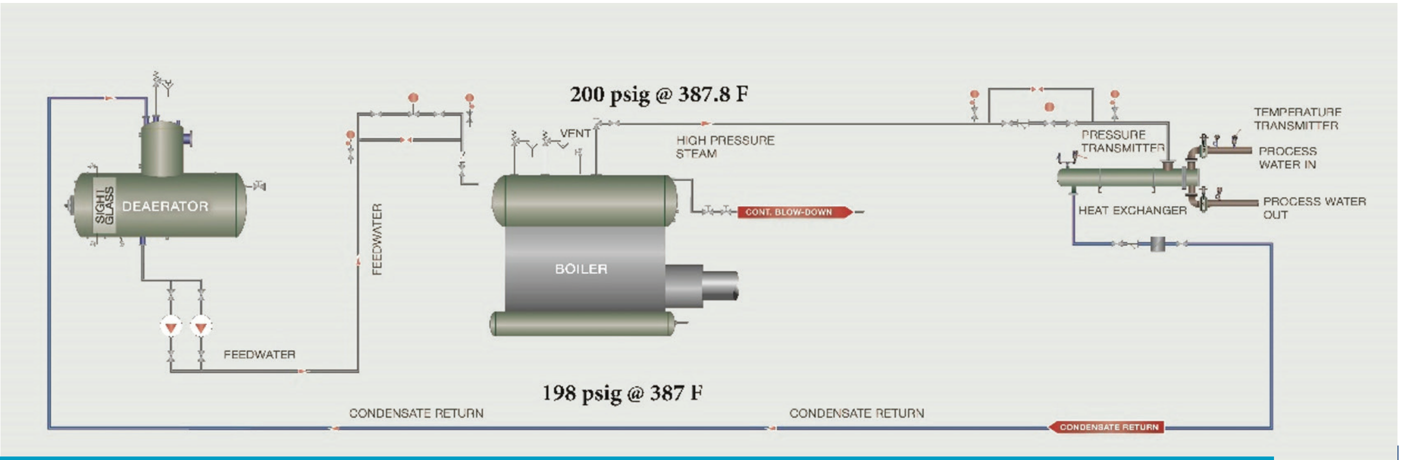

Figure 1. Close to a Perfect Steam Balance

Figure 1 illustrates a close to perfect steam balance, with 200 psig @ 387.8°F steam going out to the end users with a 198 psig @ 387°F condensate return system and a deaerator operating at 198 psig @ 387°F supplying the boilers. The end user process requires the latent energy of steam. When that latent steam is released, there is no temperature or pressure variance, and the condensate that contains the sensible energy is returned to the deaerator operation at a high pressure.

This perfect process equals the high steam thermal cycle efficiency.

However, a perfect steam balance cannot really exist for several reasons, because modulated steam pressure or flows to the process, the economics of condensate drain devices, the maintenance of condensate pressures, etc. limit how high the condensate pressure can be maintained in the return system.

3.1. Steam Balance Example 1

The following steam balance (**Figure 2**) was accomplished in a simple format, but it resulted in a substantial reduction in energy and emissions. The steam balance indicated that a pressurized condensate system could easily be instituted into segments of the process system using the current condensate system with minor capital costs, saving millions of dollars per year.

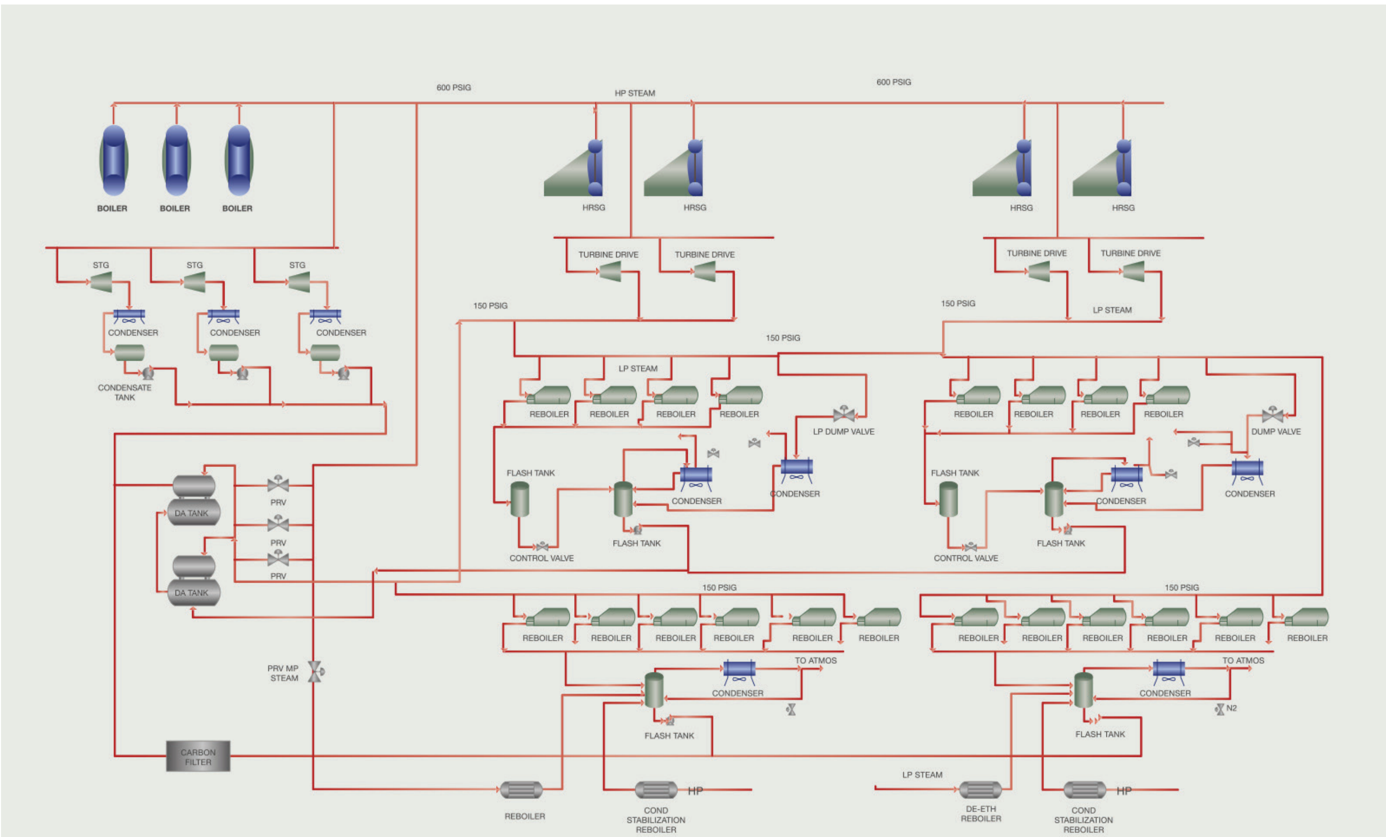

Figure 2. Example of a Steam Balance

3.2. Steam Balance Example 2

The second example steam balance in **Figure 3** determined that a few minor steam piping changes allowed low steam pressures to be consumed by end users, thus reducing the flash steam losses. Changes improved condensate drainage and further reduced the flash steam venting. The result was higher steam system thermal cycle efficiency with a reduction in energy and emissions and increased reliability.

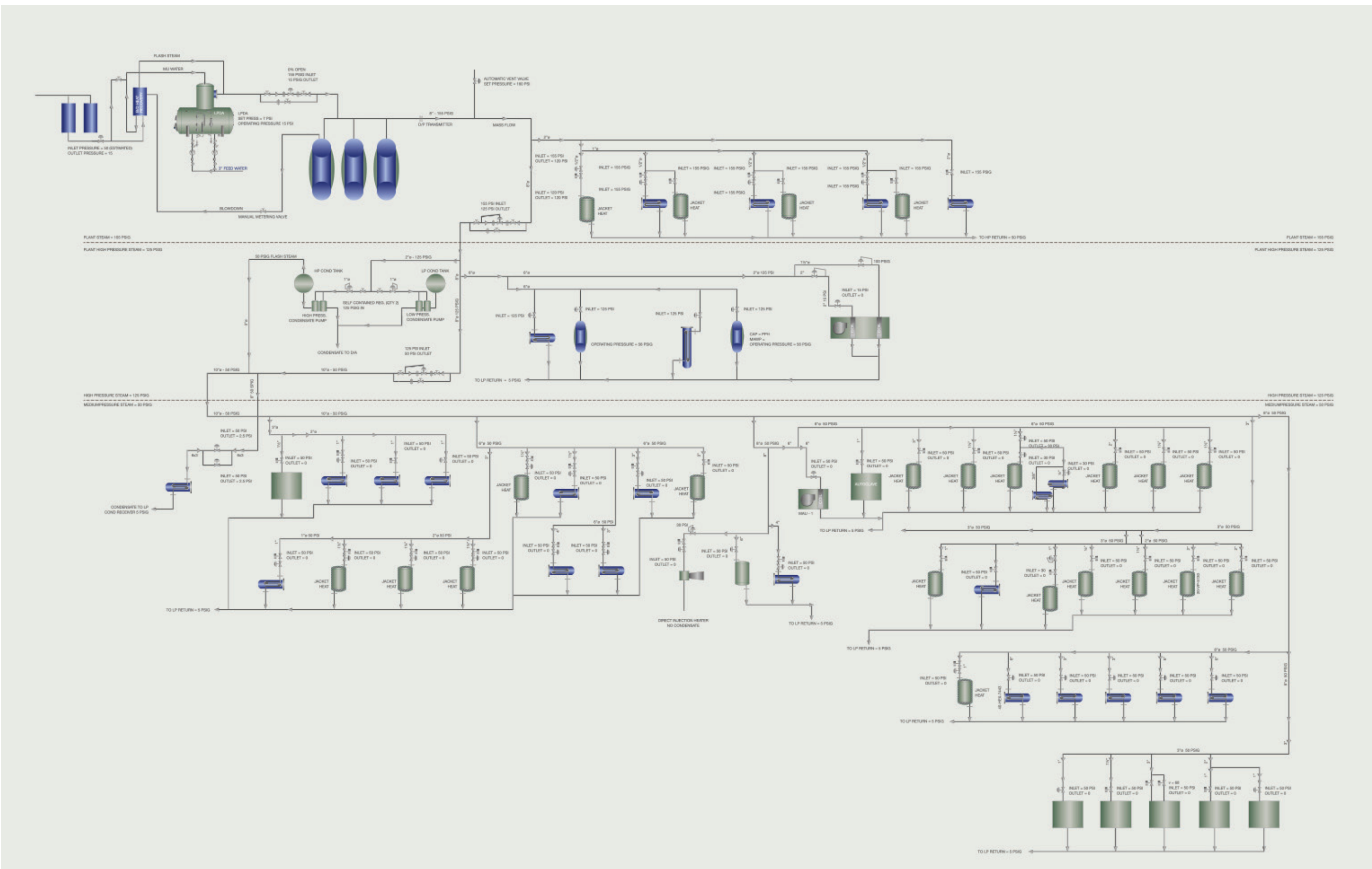

Figure 3. Steam Balance Example 2

3.3. Steam Balance Example 3

Figure 4 demonstrates different methods to recover the condensate under pressure, thus saving energy and reducing emissions for the plant operation. Switching from a low-pressure deaerator to high-pressure deaerator with condensate line changes allowed the return of condensate from nonmodulating processes to the high-pressure deaerator, resulting in higher steam system cycle efficiency.

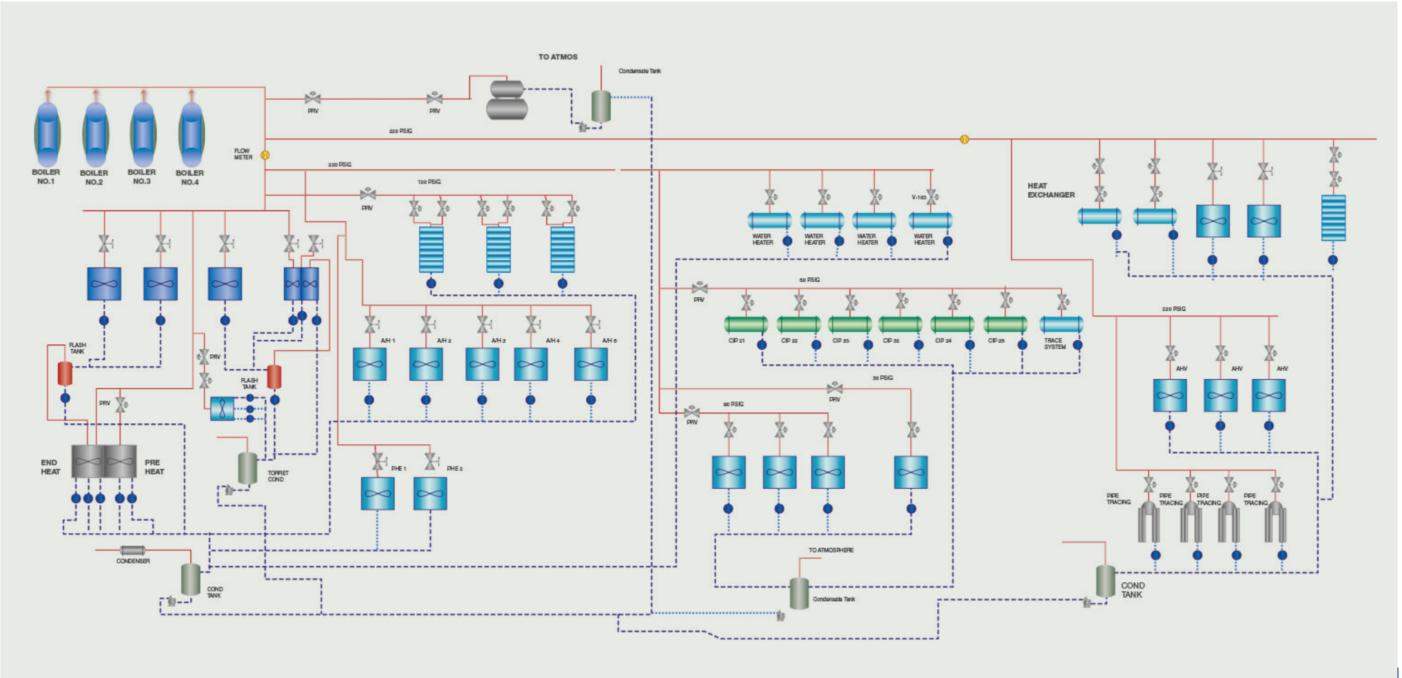

Figure 4. Steam Balance in Microsoft Visio

4. WHAT ARE THE GAINS WITH A STEAM BALANCE?

1. Knowledge of the steam and condensate system

2. Ability to set a road map for change to improve the system

3. Energy efficiency

4. Reduction in emissions

5. Increase in reliability

A steam balance is similar to the dashboard of your car: it will provide the drivers of the steam and condensate system with all information required to operate safely and efficiently.

5. STEPS FOR THE STEAM BALANCE

A steam balance flow document provides all the steam/condensate information, such as steam flows, pressures, end users, pressure reduction stations, turbines, boilers, condensate tanks, etc.

The more detail added into a steam balance flow diagram, the more important the document becomes to the plant operation.

Document the following items:

1. All boilers or steam generators
- **a.** Steam output
- **b.** Operating steam pressures
- **c.** Safety valve set pressure

2. Deaerator system
    a. Operating pressure
    b. Steam flows

3. Make-up water system for the deaerator
    a. Flow rates
    b. Average temperature

4. Steam turbines
    a. Supply pressures
    b. Extraction pressures
    c. Electrical or drive output

5. Steam headers by operating pressure

6. Steam pressure letdown stations
    a. Inlet and outlet pressures
    b. Maximum and minimum flow rates

7. End users or consumers
    a. Energy requirements
        i. Maximum and minimum

8. Condensate headers
    a. Operating pressures
    b. Flow rates

9. Flash tanks
    a. Integration into the system
    b. ASME stamping

10. Condensate tanks
    a. Venting or not venting
    b. Pressure ratings

11. Etc.

The list will grow as the steam balance process continues.

CONCLUSION

Every plant, regardless of size, from a small food processing plant to a large refinery, needs to prepare a steam balance in a format that works for the plant's operation. The steam balance does not have to be done in a complex software system to be beneficial to the steam system manager; it can be accomplished in a simple graphic software package. Whatever form is selected, the balance is the first step in increasing steam thermal cycle efficiency, which will reduce energy and emissions and increase profits. Today is a good day to get started: tomorrow may be too late.

For more information contact us:

Swagelok North Carolina | East Tennessee
http://nctn.swagelok.com - info@nctn.swagelok.com

Raleigh, NC 919.878.8085
Charlotte, NC 704.289.7400
Knoxville, TN 865.673.6610