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Boiler Re-circulation pumps & other traditional Constant flow applications

White paper

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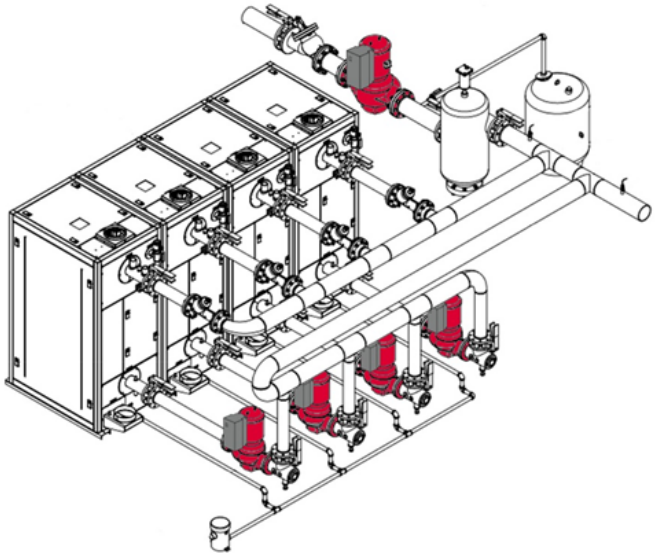


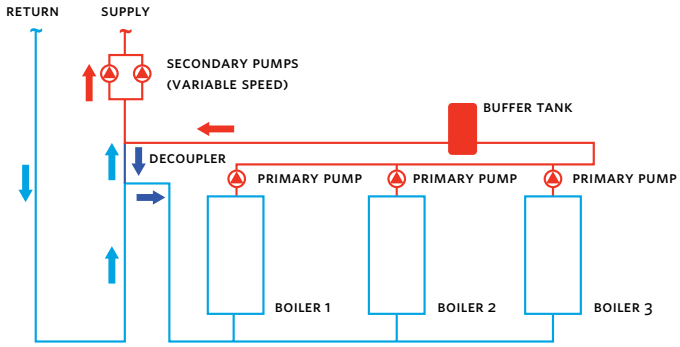
Boiler circulation pumps circulate water within the boiler to enhance boiler operation and influence the overall efficiency of the system.

Fully modulating and condensing boilers do an excellent job of maximizing both boiler electrical (blower) and combustion efficiency. However, a component to installed boiler efficiency that is often overlooked is the recirculation pump where a large savings opportunity exists.

Advances in boiler and pumping technologies like condensing boilers, cascade packages, variable speed drives on pumps, use of radiant heating/cooling systems and enhanced smart controls are helping reduce energy use and the cost of operating mechanical systems. Many new developments have combined to broadly improve system efficiency, greatly enhance energy efficiency, improve system performance and expanded equipment life cycle.

To make the primary equipment more efficient, control of Delta-T is needed and with new & responsive pump technology, we can now strive for optimal system balance.

Primary-Secondary pumping arrangement



The figure shows a typical constant primary variable secondary system consisting of three boilers running in parallel each having its own circulating pump. The Decoupler, decouples or 'hydraulically separates' the primary (boiler) and secondary (system) loops and prevents flow in one circuit from interfering with the other. Hence as zone valves open, close, or modulate, and as system pumps vary speed, the boiler loop is not impacted.

TRANSMISSION OPPORTUNITIES WITH DESIGN ENVELOPE PUMPS

Design Envelope pumps with integrated controls offer multiple opportunities & greater accuracy in flow adjustment, higher energy efficiency, and improved system stability. This paper highlights the opportunities available with Design Envelope technology for boiler recirculation pumps & other traditional constant flow applications including;

1. Reducing pumping costs
2. Boiler system performance improvement
3. Lowering installed cost/Eliminate throttling valve
4. Reducing boiler & system wear
5. Connectivity to BAS

1.0 REDUCING PUMPING COSTS

The pumps in most constant speed / constant flow systems are oversized, if balanced, the system 'balancer' reduces the system flow by a throttling valve to the original design flow.

Typically, pump heads can be oversized by 15% to 20%. If a constant speed system pump is replaced with a Design Envelope unit with integrated controls, the throttling valve can be opened wide, and the pump speed manually reduced to meet the original boiler design flow.

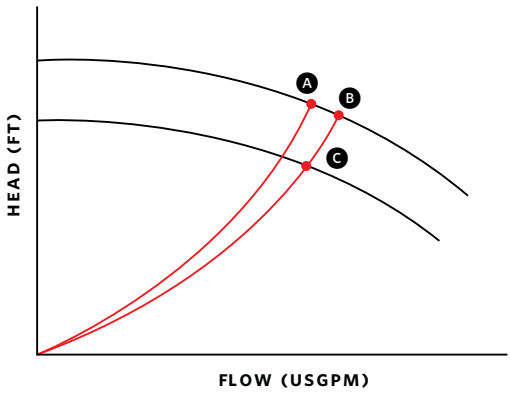
The pump would operate continuously at the new reduced speed in the constant flow system.

15% to 20% energy is saved in this manner which can recover the incremental first cost of the Design Envelope pumping unit in two to five years.

In systems which are not balanced the pump runs continuously at a higher flow lower head and the energy savings are even higher (in the vicinity of 25%) resulting in a much faster payback.

Operating cost saving opportunities

		FLOW	HEAD	BHP	EFFICIENCY	ANNUAL OPERATING COST (US$)	DE SAVINGS V/S CONSTANT SPEED
A	Constant speed throttled - Constant Flow	198	29	2.27	63.9%	885	15%
B	Constant speed unthrottled - Constant Flow	252	25	2.48	64%	967	22%
C	Reduced constant speed unthrottled (with DE) - Constant Flow	198	23	1.94	64.4%	757	—



- Analysis is based on application in a commercial office with total 3900 working hours
- Electricity cost = $ 0.10 Cents / kWh
- The head calculation includes the piping losses, strainer, check valve and the boiler pressure drop
- Raypak boiler model 3503 – operating at 30 Deg.F Delta T considered

Point A is the normal situation for most of today's installed systems with constant speed pumps. The overflow caused by over-sized pumps is throttled to the design flow.

Point B shows an un-throttled system with pump running away from the design flow for all of its working life

Many such systems could take advantage of installing a Design Envelope unit with integrated controls, opening the throttling valve and operating at a lower speed to achieve design flow. Point C

The analysis indicates that with Design Envelope pumps there exists opportunities for annual operating cost savings of 15% over a constant speed throttled system and 23% against a constant speed unthrottled system.

Sensorless constant flow

The integrated intelligent Design Envelope controls provide further enhanced features that can be leveraged during the commissioning and operation of the system.

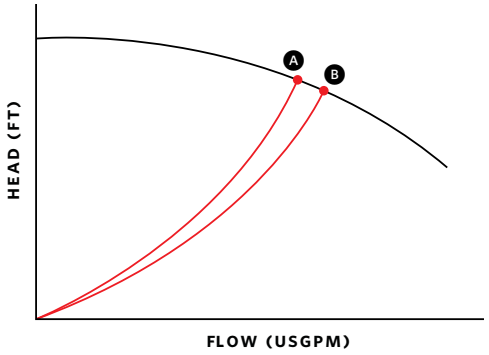
The Design Envelope pumps can be set to maintain a constant flow through the boiler, independent of system pressure changes. The performance of the modulating boiler remains at its design peak.

With the sensorless constant flow control, a constant flow is maintained through the boiler, and is independent of any pressure fluctuations due to boiler sequencing in multiple boiler systems, thus saving energy.

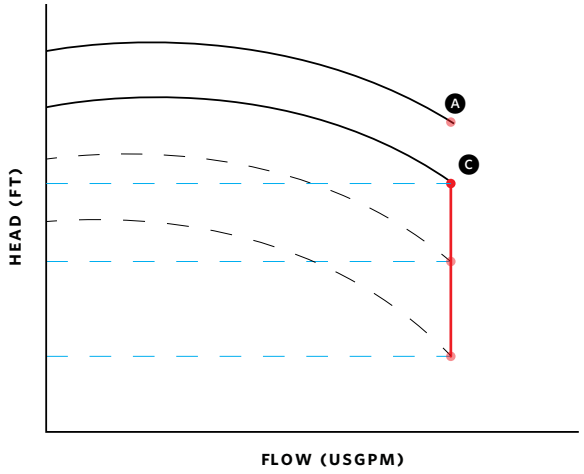
This also stabilizes the operation of the system in particular the flow through the boilers and in maintaining the return water temperature to the boiler which is essential for condensing.

Factory setting & testing and plug & play operation with the Design Envelope pumps assumes significance considering the huge effort involved in getting the proper flow & head in a throttled or un-throttled system at site.

TRADITIONAL PUMP CURVE



SENSORLESS CONSTANT FLOW PUMP CURVE



2.0 BOILER SYSTEM PERFORMANCE IMPROVEMENT

Typically modern condensing boilers require a delta-T (difference in temperature between outgoing and return water) of about 30°F (17°C) to operate effectively.

Over-pumping will cause it to lose efficiency to the point where it may not condense at all. This is an enormous waste of the additional cost of the condensing boiler and will probably shorten the life of both boiler and pump.

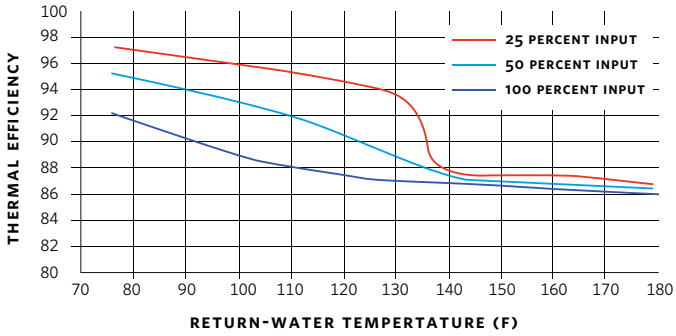
With overdesigned systems, the design point ends up drifting to the right of the curve. The flow is higher and the head is lower than anticipated requiring throttling. With Design Envelope, the pump speed can be reduced to meet the original system design flow preventing over-pumping

The Design Envelope pumps with integrated controls can be set to maintain a constant flow through the boiler, independent of system pressure change, ensuring that both the boiler and pumps run most efficiently with the performance of the modulating boiler remaining at its design peak.

Driving return water temperature down

Two main points can be gleaned from the figure which depicts a typical efficiency curve for a condensing boiler relative to return-water temperature;

TYPICAL EFFICIENCY CURVE FOR A CONDENSING BOILER RELATIVE TO RETURN-WATER TEMPERATURE



To achieve maximum efficiency, condensing boilers must be able to achieve condensation of exhaust gas on the heat exchanger. To do this, the circulating water's temperature upon return to the boiler must be as cool as possible. The cooler the returning water, the greater the rate of condensation and the higher the efficiency of the boiler. Peak efficiency is achieved with return water temperatures as low as 75 - 80°F. Efficiency declines dramatically as return water temperatures rise beyond 130°F because little condensation is possible at these high temperatures.

The second point relates to the fact that the efficiency of a condensing boiler increases as load decreases. A boiler receiving 90°F return water and operating at 100% load has a thermal efficiency of about 90%. For the same boiler operating at 25% load, efficiency increases to nearly 97%.

3.0 LOWERING INSTALLED COST/ELIMINATE THROTTLING VALVE

By adjusting flow through pump-speed adjustment with the Design Envelope pumps, in addition to energy conservation, a number of other operational benefits accrue which includes improved reliability, reduced life-cycle cost, and lower installed cost by eliminating the throttling valve and the associated piping.

4.0 REDUCING BOILER & SYSTEM WEAR

Pumping at the correct flow rates with the Design Envelope pumps result in;

- Less erosion of heat exchanger tubes
- Reduced thermal stresses on the heat exchanger
- Increase in boiler life
- Also increases the pump life as it is operating at a slower speed most of the time

5.0 CONNECTIVITY TO BAS

Design Envelope pumps are BAS ready and allows for operation in conjunction with the building automation system. Equipment installation becomes easier resulting in rapid installation and From a fault detection standpoint, it often takes about 10 days before a facilities manager notices equipment is under performing with a BAS. Without BAS, it would take much longer, if they ever realize that it was underperforming. The Design Envelope pumps thus assist in better servicing through BAS diagnostic reporting.

SUMMARY

In summary, Design Envelope pumps offer the following advantages;

- Reduce pumping costs & achieve greater energy efficiency. Easiest to use constant flow sensorless control
- Improve the boiler performance by better balancing with speed control versus imparting **false** head thus assisting in more precise flow control
- Reducing the installed cost with elimination of throttling valves in the system
- Reducing boiler & system wear & improving equipment longevity by reducing pump speed and matching to the load requirement
- Enhanced connectivity and integration of BAS communication

Finally, though the fully modulating and condensing boilers do an excellent job of maximizing both boiler electrical (blower) and combustion efficiency, a large savings opportunity exists by using a variable speed boiler recirculation pump that is load matched to a modulating boiler's combustion system.

In boiler installations today, the pumps are sized to match the flow required for boilers firing at full rate. In this scenario, pumps will run at full speed every time the boilers fire, regardless of the actual flow required by the boilers.

With future expected changes in boiler control strategies, the Design Envelope pumps can accept a 0-10VDC signal from the boiler control and can dramatically reduce the electrical usage of the boiler pump & greatly enhance total boiler installed efficiency by load matching boiler & pump operation.

This would also protect the boiler's most essential component-the heat exchanger-by ensuring the variable speed boiler pump remains in phase with the boiler's combustion modulation.

Similar advantages with the Design Envelope technology also apply to other traditional constant flow applications including reheat coil circulating pumps, condenser water pumps, primary chilled water pumps, domestic hot water heating and snow melting, amongst others which run at constant speed and expend huge amount of energy.

These pumps as in most constant speed/constant flow systems are oversized necessitating in reducing the system flow by a throttling valve to the original design flow. With Design Envelope pumps, the pump speed can be manually reduced to meet the original system design flow. The pump would operate continuously at the new reduced speed saving significant amount of energy in comparison to throttled & un-throttled systems.

By adjusting flow through pump-speed adjustment with the Design Envelope pumps, the throttling valve and associated piping can be eliminated.

With the Design Envelope pumps and operating the motor and pump at lower speeds results in less wear on motor and pump seals and bearings.

The ability to connect Design Envelope pump to a BAS is an advantage since more and more buildings are BAS-enabled. This also assists in better servicing through BAS diagnostic.

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