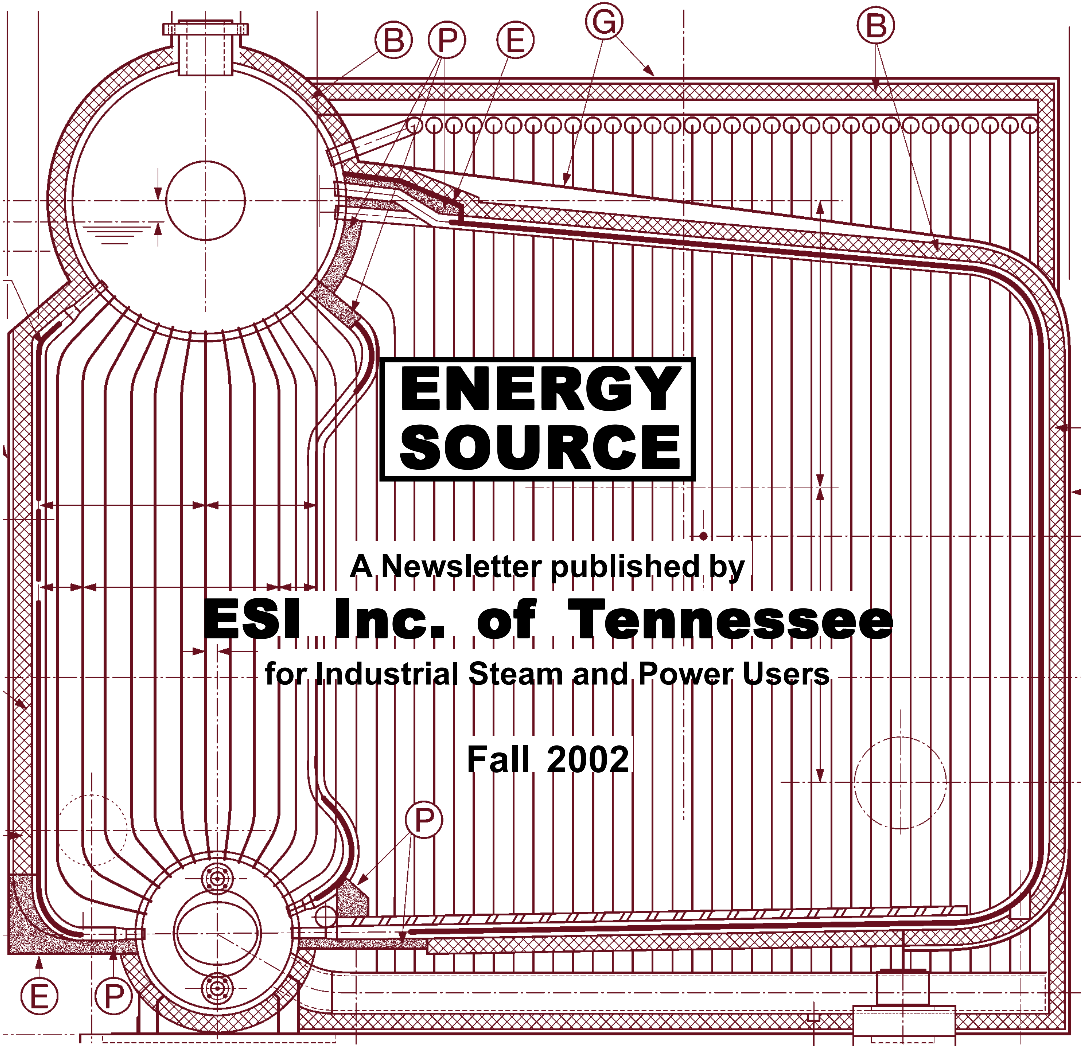


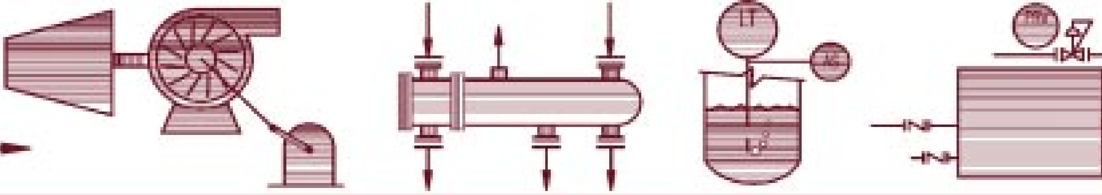
ENERGY SOURCE

A Newsletter published by

ESI Inc. of Tennessee

for Industrial Steam and Power Users

Fall 2002



Cogeneration – Pump Selection

By: Patrick M. Hayes, P.E., Project Systems Engineer, ESI

Although there are many elements (and pieces of equipment) which constitute a successful cogeneration project, there are only a few critical components which can cause complete failure of the system to operate per its original design. Because the turbine-generator, cooling devices, heat recovery steam generator (or boiler), and emissions control equipment are relatively "high cost" pieces of equipment, they typically receive the most time and attention in the design phase. While many of the "lower cost" pieces of equipment are very flexible and forgiving in operation, we have discovered that one of the most common factors hindering success in the commissioning of cogeneration projects are the smaller pieces of rotating equipment – namely pumps, blowers, and fans. This article will address pump selection.

The three most obvious factors determining pump selection are the type of liquid to be moved, the flow (capacity), and the pressure (head) required. Successful pump selection will also require the correct design for application (pump type), suction conditions (flooded, lift, etc.), materials of construction, recirculation or pressure relief, and piping design. These factors are the bare minimum for successful performance while many other decisions must be made which will have influence on the economics, operational reliability, and maintenance of the pumping system including: sealing, bearing type, drive selection, cooling system, lubrication, pump mounting and foundation, coupling type, and redundancy needed for the system.

Pump Application

The first critical decision in pump selection is the type of pump to use. There are two distinct types of pumps classified by the method each uses to transfer energy to the fluid. **Positive Displacement Pumps** discharge a fixed volume of liquid for each stroke or revolution of the pump and therefore add energy intermittently to the fluid. The most common types of positive displacement pumps are *reciprocating* (which use plungers, pistons, diaphragms, or bellows) and *rotary* (which use gears, vanes, screws, lobes, or progressing cavities). **Kinetic Pumps** impart kinetic energy to the fluid and then transform the kinetic energy to fluid static pressure energy. The pumping mechanism adds the kinetic energy and the pump housing or shell transforms the energy to fluid static pressure on a continual basis. Kinetic pumps include centrifugal, jet and ejector varieties, with centrifugal being the most common.

There are advantages and disadvantages for both positive displacement pumps and kinetic pumps. Generally, positive displacement pumps have a lower flow rate and generate a higher pressure for each stage while moving a constant volume in a pulsing discharge. Positive displacement pumps are self-priming and work better with highly viscous fluids than kinetic pumps. Kinetic pumps typically have a higher flow rate with lower pressure generated per stage and are not self-priming. Centrifugal pumps are not as effective at moving highly viscous fluids; however, the constant rotation of the impeller produces a steady (non-pulsing) discharge stream and a constant pressure at a given rate of flow.

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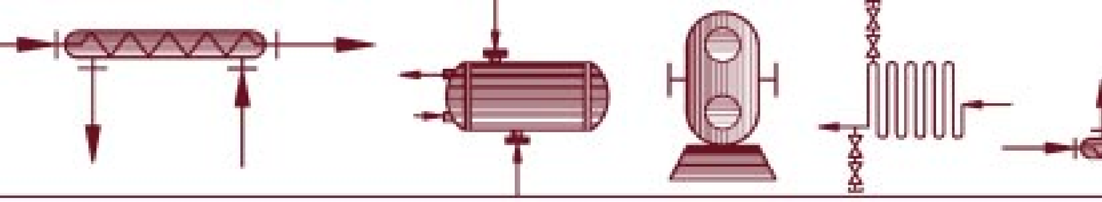
ENERGY SOURCE

The *ENERGY SOURCE* is published quarterly for customers, employees, and friends of ESI Inc. of Tennessee.

ESI is the Steam and Power *SPECIAL FORCES®* providing clients with innovative, cost-effective, and environmentally-friendly solutions.

If you have any suggestions or comments about the newsletter feel free to call us at 770-427-6200 or e-mail us at energysource@esitenn.com.

Deanna White
Managing Editor



ESI Announces New Comprehensive Operator Training Program

By: Deanna White, Marketing Manager, ESI

I am pleased to announce that ESI has added another dimension to our Service Solutions – a comprehensive Operator Training Program. ESI has always felt that an essential part of executing the complete design and construction of a steam and power generation facility is the development of a comprehensive and specific Operator Training Program. Throughout our 20 plus years of designing and building steam and power generating facilities, ESI has provided training to every operating staff for every project that we have completed. Proper operator training could save your company a great deal of time, money, and could potentially mitigate losses from improper operation of your facilities powerhouse.

Over the years, ESI has found that in many instances powerhouse personnel have not received adequate training to truly understand their actions and the consequences of those actions. In many cases, the older employees who were truly experts in the plant operation have retired or been promoted and despite best efforts, their experience has not been passed on to the new operations staff. This occurrence coupled with corporate America's need to downsize in order to reduce operating expenses has often left powerhouses in jeopardy from lack of understanding of the risks associated with operating a steam or power generating facility.

ESI's Steam & Power *SPECIAL FORCES®* Operating Training Program consists of three levels of training: Basic, Advanced, and Recurrent.

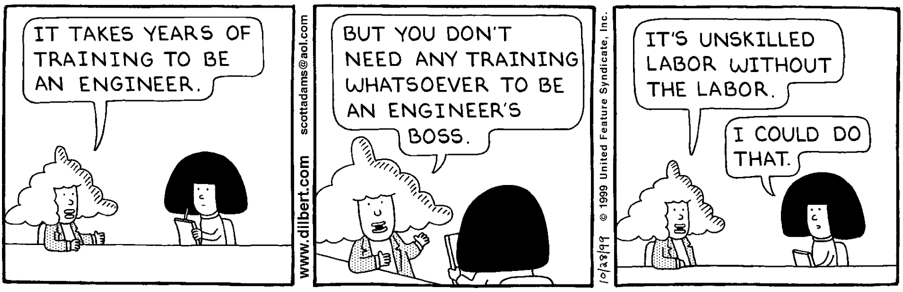
- **Basic Training –** Training on powerhouse components including boilers, water treatment systems, steam and combustion turbines, burners, etc.
- **Advanced Training –** Training customized for your particular powerhouse facility. ESI will visit your site, then develop a comprehensive training program for your facility.
- **Recurrent Training –** Recurrent annual training for your operators, plus ESI will be on-call 24/7 to your operations staff to answer questions and troubleshoot problems.

Following are a couple of quotes from clients that have entrusted their operations staff to ESI's training system:

"ESI's training system is a very good tool for safe and reliable operation of our steam facility" - *Potlatch Corporation*

> *" ESI implemented their training system for our facility in 1995 and we are still using it today"*- Major Worldwide Brewery

If you are interested in discussing a training program for your operating personnel, please contact Deanna White at 770-427-6200 or via e-mail at info@esitenn.com.



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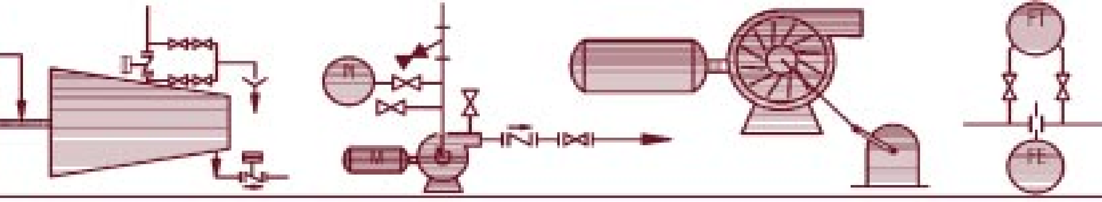


MACT Compliance

What Are Your Plans?

By: Jeffrey H. White, P.E., Vice President of Sales, ESI

In the year 1999, the Federal EPA promulgated new NOx emission compliance standards that required the significant reduction of NOx emissions from numerous industrial and small utility boilers. Many companies are in the process of complying with that new standard as the compliance date approaches. ESI initially performed numerous engineering studies to define for our customers the technology and cost requirements associated with complying with these new standards. ESI currently is executing projects which include the installation of new low NOx burners and SNCR technology to assist our customers in meeting these new NOx emission compliance standards.

The Federal EPA is currently finalizing new MACT (Maximum Achievable Control Technology) Standards which will mandate the reduction of Mercury, HCl, and TSP (Total Suspended Particulate) emissions. These new MACT standards will affect almost all existing coal and heavy oil-fired boiler installations and are due to be published late this year with promulgation scheduled for November 2003. Emission sources are being required to provide the EPA with their expected strategy to comply by submitting preliminary permit modifications by May 15, 2003.

As of this writing, the current anticipated new emission limits for existing coal and heavy oil fired installations will be as follows:

- TSP – 0.07 lbs per million btu heat input
- HCl – 0.09 lbs per million btu heat input
- Mercury – 4 lbs per trillion btu heat input

ESI is currently performing engineering studies for customers that desire to evaluate their cost and technology options to meet these new standards. These companies are interested in reacting quickly once the new standards are mandated so that the cost of conversion can be minimized before limited market capacity drives up prices. If you have coal or heavy oil-fired boilers that will be affected by these new MACT standards, ESI would be pleased to discuss the current status of the regulations, anticipated emissions levels, and a plan on how your company can begin a program for eventual compliance. If interested, please contact Jeff White at 770-427-6200 or via e-mail at info@esitenn.com.

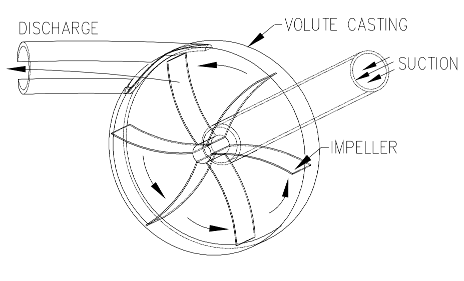
ESI Launches New Web Site

ESI is excited to announce the launch of our new Corporate Web Site on October 18, 2002. The new site is a complete redesign with expanded features in many areas including: a comprehensive project case studies section; an up-to-date rental equipment section; updated operator tests featuring questions along with answers and explanations; and much more.

Visit our site soon to see why we call ourselves the Steam & Power *SPECIAL FORCES*®!

Cogeneration - Pump Selection... *Continued from Page 1*

The majority of pumps in the cogeneration facility will be centrifugal because of the relatively high flow compared with moderate head required and the need for a constant (non-pulsing) feed. This includes boiler feedwater pumps, hotwell pumps, cooling water pumps, make-up water pumps, condensate return pumps, and others. For the remainder of this article we will concentrate on the centrifugal pump.



Simplest Form of a Centrifugal Pump

Flow (Capacity) and Pressure (Head)

Flow (capacity) and pressure (head) of the liquid to be pumped will be determined by the design of the system and the results of the mass and energy balance. The term "head" refers to the pressure of the system represented as the hydrostatic pressure of an incompressible fluid as a function of vertical depth and density of the fluid. More simply, head refers to the equivalent height of a column of water, in feet, needed to produce a certain pressure (pressure varies linearly with depth, is independent of the volume or shape of the water column, and at any point has the same magnitude in all directions).

Proper pump design must account for not only maximum operating conditions, but also normal operation and minimum conditions. The pump curves must be matched to system needs throughout the range of pump operation. Factors such as minimum required pump flow must be considered as well as pressure relief for maximum pressure (head) conditions. Design safety margins (multiplicative factors) are typically applied to the maximum flow and head values to ensure continued pump operation in upset conditions. It is important not to over-inflate these safety margins as an oversized pump will operate with less efficiency and will have a higher capital and operating cost.

Net Positive Suction Head (NPSH)

For centrifugal pumps, one of the most important and least understood factors is Net Positive Suction Head (NPSH). In general a *suction head* exists when the liquid supply level is above the pump centerline and a *suction lift* exists when the liquid supply level is below the centerline of the pump. *Total suction head* (or lift) is the absolute pressure at the surface of the liquid supply level (barometric pressure for an atmospheric tank and absolute pressure for a closed tank) plus the height that the liquid supply level is above the pump centerline (a negative number for suction lift conditions) minus all pressure losses in the suction line (including friction loss of pipe, entrance and exit losses, valve losses, etc.).

The design of the centrifugal pump limits its ability to prime itself and the high speed of the impeller tends to create a low pressure zone in the eye of the impeller which can cause liquids with a saturated vapor pressure near pump operating pressure to flash into gaseous form. This results in cavitation that can quickly destroy a pump, a phenomena not uncommon to boiler feedwater pumps. For a centrifugal pump, NPSH (which must be a positive number) equals the total suction head minus the absolute vapor pressure (in feet) of the liquid being pumped.

There are two measures of NPSH which must be considered for centrifugal pumps; Net Positive Suction Head required (NPSHr) and Net Positive Suction Head available (NPSHa). The first value NPSHr is determined by the pump design and is a function of many factors including impeller and casing design, pump flow, and fluid

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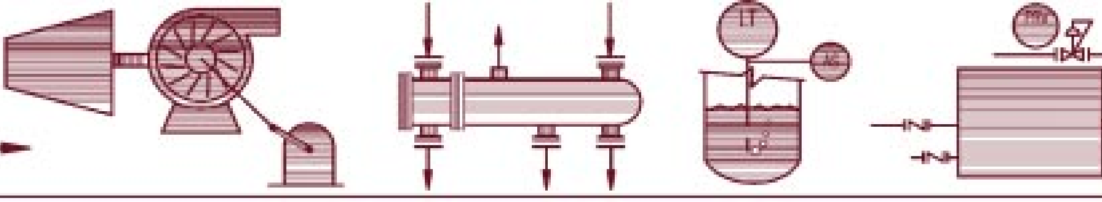

Cogeneration - Pump Selection... *Continued from Page 4*

conditions. The second value, NPSHa, is determined by the design of the system and must be greater than the value of NPSHr for the centrifugal pump to work.

As you can see, selection of a pump is therefore a function of both the pump designs available and the system design constraints (i.e., height of liquid level, liquid temperature, line losses, etc.).

Materials of Construction

The liquid to be pumped and the environment in which the pump will operate determine the materials of construction for the pump, casing, seals, etc. The corrosive (or abrasive) nature of the liquid, pH, temperature, erosion, and pressure will all play roles in determining what materials will be required for both the casing and rotating assembly in the pump. The pH of a liquid is a measure of its corrosive nature based on whether the fluid is more acidic (pH less than 7) or basic (pH greater than 7). Distilled water has a neutral pH of 7. In general, for pH values between 4-10, Iron, Stainless Steel, Bronze, and Carbon Steel may be used; however, pH values below 4 and above 10 will require more resistant alloys. Erosion is high velocity induced wear of the surface of the material. Erosion is a function of the fluid velocity; however, it can accelerate other forms of corrosion or abrasion (the destruction of material from solid particles entrained in the liquid).

Pump Seals

Seals are of great importance to the long-term success of any pump application. Seals are classified as being static or dynamic. Static seals are used in areas where there is no significant movement at the seal joint. Gaskets and O-rings are typically used for static joints. Dynamic seals are used where there is movement between the two surfaces to be sealed. In centrifugal pumps, dynamic seals are used where the rotating pump shaft penetrates the pump casing. Typically this dynamic seal is accomplished with compression packing or mechanical seals. The decision to use compression packing versus a mechanical seal can have long-term economic impact for reliability, maintenance, and spare parts inventory. The mechanical seal is a more expensive initial cost, but has several distinct advantages which can help overcome this initial capital outlay. The mechanical seal works better at higher pressures, reduces friction and power loss, eliminates shaft wear, and eliminates leakage of product. This is especially useful with corrosive liquids when trying to comply with health, safety, and environmental regulations.

Piping Design

The last basic design consideration we will discuss is piping design which will have an important effect on both the suction and discharge sides of the centrifugal pump. Piping system head loss must be considered in the initial pump selection not only to ensure sufficient available NPSH, but also to ensure that the pump has been designed with enough head to overcome all the system pressure drop in the discharge line. This pressure loss will include friction loss in the pipe as well as pressure drop through all valves, strainers, and instrumentation, and the head loss (or gain) from change in elevation from the pump centerline. Pipe velocities for the suction side should be in the 3-6 feet per second range with discharge velocities in the range of 6-10 feet per second (however, discharge velocity is largely a decision based on the tolerable friction loss in the pipe). The suction side design should try to avoid excessive fittings which could cause uneven flow patterns to the eye of the impeller leading to vibration, possible cavitation, and shaft deflection.

In this article, we have tried to address some of the major considerations in the proper selection and application of pumps in the cogeneration facility. Obviously, we did not cover the myriad of plant-specific design issues that every facility faces. In the next article we will discuss the specific issues involved in the design and operation of boiler feedwater pumps, hotwell pumps, and cooling water pumps.