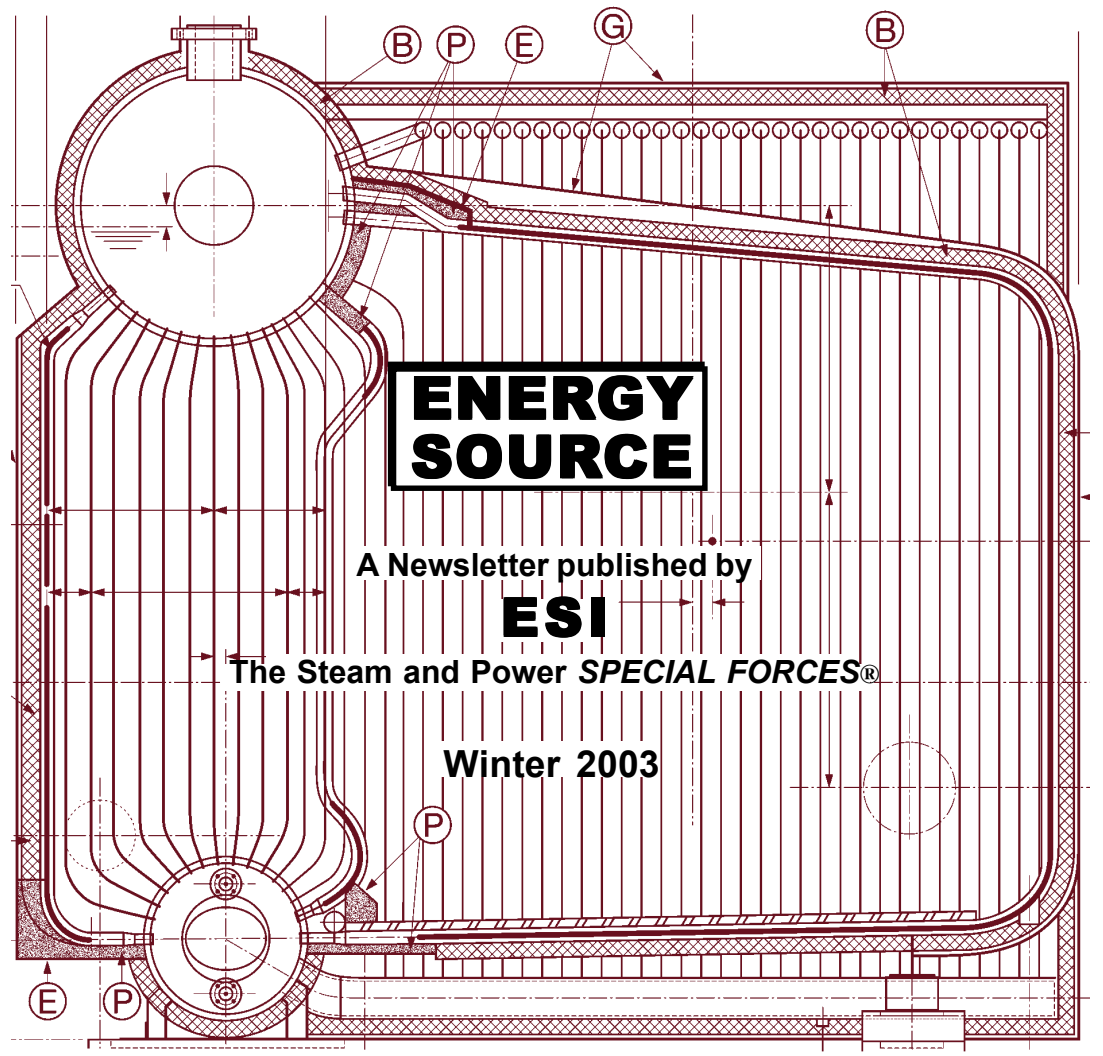

ENERGY SOURCE

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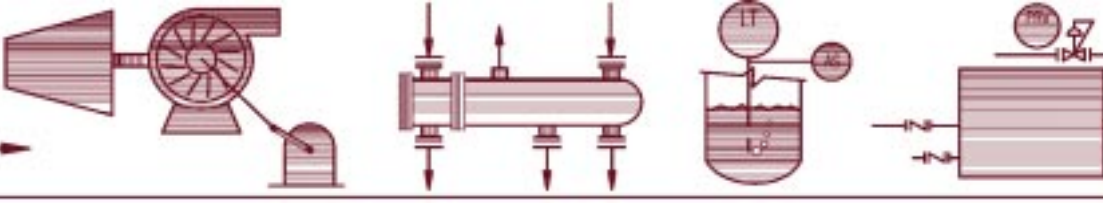
The Steam and Power *SPECIAL FORCES*®

Winter 2003



Cogeneration – Pump Operation

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

Editor's note: The Fall 2002 Issue of the ENERGY SOURCE discussed pump theory and proper pump selection. The following article will concentrate on operation and maintenance of the Centrifugal Pump which is the most common pump used in a cogeneration system.

Three of the most important types of centrifugal pumps found in a cogeneration system are boiler feedwater pumps, cooling water pumps, and hotwell pumps. These pumps come in a variety of sizes, shapes, and designs. The pumps may be motor driven or steam turbine driven and may have either direct coupling of drive to pump or any variety of indirect means of coupling including belt, reduction gear, or clutch. Even with all these differences, the pumps have several common design features which require operator attention to ensure successful long-term operation.

Lubrication of bearings, drive, and coupling are of critical importance to the extended life of any pump. The first step is to select the appropriate lubrication. The temperature at which the pump operates is of critical importance when selecting the type of lubrication. The pump and lubricant manufacturers have specific guidelines about the amount and frequency that the lubrication should be replaced in order to ensure that the pump is maintained in a manner which will maximize the life of rotating parts.

Recirculation is also of critical importance for centrifugal pumps. A minimum flow must be maintained through the pump to avoid overheating and cavitation. This is especially critical for boiler feedwater pumps and hotwell pumps which transport water at high temperatures with fluid pressure very close to the pressure of vaporization. If the fluid pressure becomes equal to the pressure of vaporization (either through increase in water temperature or decrease in water pressure) tiny vapor bubbles will start to form and collapse creating a condition known as cavitation. Cavitation poses two serious threats to the centrifugal pump. The formation and collapse of these tiny vapor bubbles will cause rapid pitting and erosion of the wetted parts of the pump which may result in failure of these parts and destruction of the pump. The second threat posed by cavitation is the rapid unbalancing of the pump due to loss of prime or vapor lock in the suction eye of the impeller. This unbalanced condition will cause an overloading of the thrust bearing which in turn can destroy bearings, rotating assembly, and even the pump drive.

The most common reason for cavitation to occur during pump operation is a sudden dramatic decrease of fluid flow through the pump. Energy is constantly imparted to the fluid by the pump and during normal operation this energy is transferred to the fluid to cause it to flow through the system. However, if this flow is decreased or stopped, the energy will act to increase the fluid pressure and temperature until the fluid reaches the temperature of vaporization and cavitation occurs. There is a certain flow rate above which cavitation should not occur; therefore, the system should be designed to maintain this "minimum" flow rate. The minimum flow is normally established through use of an orifice or automatic valve which "recirculates" fluid to the reservoir source of suction for the pump.

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ENERGY SOURCE

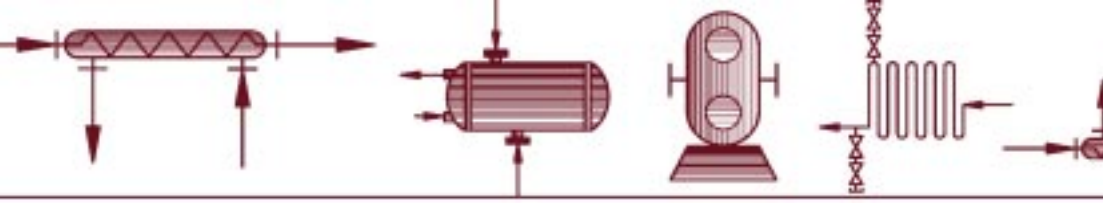
The *ENERGY SOURCE* is published quarterly for customers, employees, and friends of ESI Inc. of Tennessee.

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.

Happy New Year

Deanna White
Managing Editor



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

Following are several more "**tricks of the trade**" which should be considered when operating and maintaining centrifugal pumps:

- Always start a centrifugal pump against a closed or throttled valve to ensure that the pump does not induce a shock wave into the piping system upon start-up.
- Anytime the pump and driver are being realigned, check to see if the manufacturer recommends an off set alignment. With the pump and driver having differential temperatures between cold and operating conditions and with a different centerline of shaft to bearing mounting point dimensions, it is common for either the pump or driver to be set high or low during a cold alignment. It is also a good idea to perform a "hot" coupling check if possible.
- Check the strainers used for pump service periodically to see if they are doing their job and intercepting any foreign material in the system before it damages critical components. Often these strainers are ignored until abnormal operating conditions are noticed. Make it a habit to check these strainers periodically *before* they affect system performance due to restriction.
- Make sure to thoroughly vent the pump casing *as well as* the suction and discharge lines for the pump when placed into service. Air pockets which form in the pump or piping can lead to cavitation in the pump as well as possible damage to the downstream systems.
- On pumps which use compression packing for the shaft seal, NEVER use packing with a wire bracing in the packing material because this wire can score or destroy the pump shaft at high rotational speeds.
- If possible, maintain vibration logs for all rotating equipment. Vibration analysis is an invaluable tool to predict preventive maintenance and avoid possible failure of pumps and fans in critical applications. These logs should be taken in both normal operating conditions as well as during periods of troubleshooting to best understand the system.
- Keep a copy of the pump curves for troubleshooting activities. The pump curves will allow the operations personnel to predict flow, pressure developed, horsepower, and pump efficiency. This can often help explain certain operating conditions as well as inform the operator if a pump is not operating as designed, indicating problems with the pump itself rather than the surrounding system. (Tip: Be sure that the pump curve has the *actual impeller size* plotted – not just the *minimum* and *maximum* impeller sizes for that pump.)
- If possible, dowel the pump to its base plate. This serves several purposes. The dowel will help reduce alignment problems after a pump has been removed for maintenance to ensure no load is transferred to the pump via the piping connections. The dowel will also help reduce any movement of the pump on its base plate due to vibration of the equipment.
- Finally, the pump is a function of the system in which it operates. Be sure to check both upstream and downstream conditions of the system when commissioning or troubleshooting pump operation. Often the pump will be adversely affected by the system and will manifest symptoms caused by upset conditions somewhere other than in the pump itself. This includes but is not limited to:
  - Changes in pressure of either the discharge or suction systems
  - Increased/decreased pressure drop through the system
  - Failure/disrepair of control valves
  - Leakage through system valves
  - Cycling of the process

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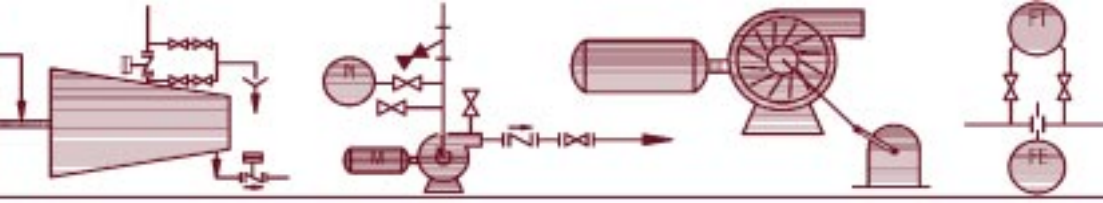
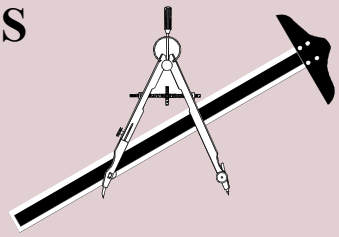


DESIGN TIPS



In the powerhouse environment, it is very important to utilize the proper enclosure for electrical and control equipment. The National Electrical Manufacturers Association (NEMA) developed a standard, NEMA 250-1997 "Enclosures for Electrical Equipment (1000 Volts Maximum)" to categorize enclosures by the environmental conditions they are designed to protect against. The two charts below illustrate the enclosure rating and the protection associated with it. Both tables apply only to nonhazardous locations. Table 2-1 is for enclosures installed indoors. Table 2-2 is for enclosures installed outdoors. It should be noted that these ratings will only be valid if the enclosure is properly installed.

Table 2-1

[From NEMA 250-1997]

Comparison of Specific Applications of Enclosures for Indoor Nonhazardous Locations

Provides a Degree of Protection Against the Following Environmental Conditions	Type of Enclosure									
	1*	2*	4	4X	5	6	6P	12	12K	13
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X	X	X	X
Falling dirt	X	X	X	X	X	X	X	X	X	X
Falling liquids and light splashing	...	X	X	X	X	X	X	X	X	X
Circulating dust, lint, fibers, and flyings **	...	...	X	X	...	X	X	X	X	X
Settling airborne dust, lint fibers, and flyings**	...	...	X	X	X	X	X	X	X	X
Hosedown and splashing water	...	...	X	X	...	X	X	...	...	...
Oil and coolant seepage	...	...	...	...	...	...	...	X	X	X
Oil or coolant spraying and splashing	...	...	...	...	...	...	...	...	...	X
Corrosive agents	...	...	...	X	...	...	X	...	...	...
Occasional temporary submersion	...	...	...	...	...	X	X	...	...	...
Occasional prolonged submersion	...	...	...	...	...	...	X	...	...	...

* These enclosures may be ventilated.

** These fibers and flyings are nonhazardous materials and are not considered Class III type ignitable fibers or combustible flyings. For Class III type ignitable fibers or combustible flyings see the National Electrical Code, Article 500.

Table 2-2

[From NEMA 250-1997]

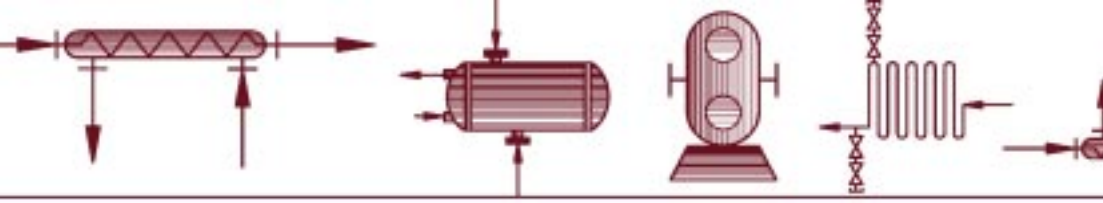
Comparison of Specific Applications of Enclosures for Outdoor Nonhazardous Locations

Provides a Degree of Protection Against the Following Environmental Conditions	Type of Enclosure						
	3	3R*	3S	4	4X	6	6P
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X
Rain, snow, and sleet**	X	X	X	X	X	X	X
Sleet***	...	...	X	...	...	...	...
Windblown dust, lint, fibers, and flyings	X	...	X	X	X	X	X
Hosedown	...	...	...	X	X	X	X
Corrosive agents	...	...	...	...	X	...	X
Occasional temporary submersion	...	...	...	...	...	X	X
Occasional prolonged submersion	...	...	...	...	...	...	X

* These enclosures may be ventilated.

** External operating mechanisms are not required to be operable when the enclosure is ice covered.

*** External operating mechanisms are operable when the enclosure is ice covered.



Project Options . . . Capital Costs

By: Deanna B. White, Marketing Manager, ESI

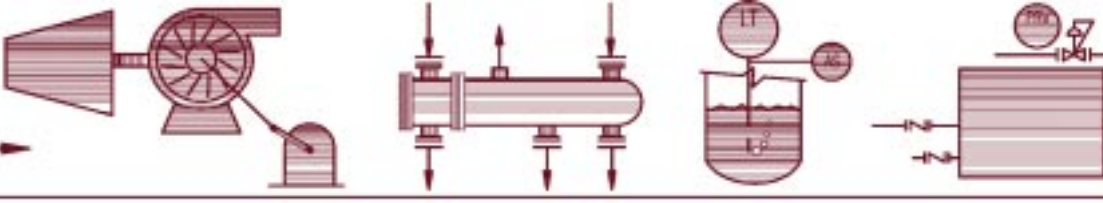
If your plant situation has recently changed due to higher fuel or power costs, or if you are being mandated to comply with recent environmental regulations, ESI can perform a low cost engineering study to assist in the evaluation of your options and determine the best path forward. If you already have the scope determined, ESI provides ± 20% budget pricing as a complimentary service to our clients.

ESI engineers are industry experts when it comes to conducting project study and feasibility analysis. We are focused on the development of projects and can quickly filter through options that won't meet your company's necessary return on investment. Our typical study involves analyzing a client's current situation, brainstorming possible scenarios which will most benefit the client, determining budgetary capital and operating costs, and performing a life cycle analysis which will typically include operating costs, financing costs, depreciation and tax effects. We use this analysis to narrow the field and select the appropriate option that will offer the client the best return on investment. We then typically refine our analysis of the selected option's capital and operating costs and run the life cycle analysis again to make sure that the project is viable for funding.

Our classic study and feasibility analysis includes the technical and economic evaluation of:

- New or existing Steam Generation Systems
- New or existing Power Generation Systems
- Material Handling Systems
- Water Treatment Systems
- Instrumentation, Controls, and Electrical Systems
- Environmental Compliance including NSPS, MACT, Title 5 Standards Compliance
- Biomass Dryers
- Carbon Burnout Systems
- First-of-a-kind Systems utilizing new technology, plant opportunity fuels, etc.

For additional information about budget pricing, or conducting an engineering study and feasibility analysis, please give Jay Garrett or Jeff White a call at 770-427-6200. We look forward to hearing from you.

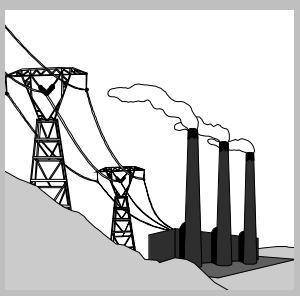


Cogeneration - Pump Operation... *Continued from Page 2*

Troubleshooting for pumps is a straightforward process which should begin with an investigation of: what has changed in the system, how was the change discovered, how have noted changes affected the pump or driver, what can be done to recreate the original condition, and is the problem in the pump or in the system? Process flowcharts, check sheets, and cause/effect diagrams are all invaluable tools in rapid resolution of pump problems and prevention of future failures.

This general discussion on pumps is in no way meant to be comprehensive. The only truly effective way to improve facility operation is through training and experience. ESI offers an operator training program for steam and power generation facilities. Training can provide benefits in safety, efficiency, reliability, and can therefore improve the overall economics of a steam and power generation facility. Please contact ESI at 770-427-6200 or via e-mail at info@esitenn.com if you have any questions about this article or if you would like additional information about ESI's Operator Training Program.

Other Cogeneration Articles ...



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Cogeneration - Pump Selection

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Cogeneration - Combustion Turbine Selection

Spring 2002→
Cogeneration - Steam Turbine Selection

Winter 2002→
Cogeneration - Designing the Cycle

Spring 2001→
Selecting Cooling Systems For Steam Turbine Generating Facilities

Winter 2001→
To Generate or Not Generate?
That is the question that Wausau Papers in Groveton, NH recently answered.

Winter 2000→
To Generate or Not Generate? That is the question

To review these articles and other past newsletters visit the Help & Training Section of our web site at www.esitenn.com.

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