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# Helping Industry To Be Steam Smart

Steam Challenge is a voluntary, technical assistance program to help U.S. industry become more competitive through increased steam system efficiency. Its goal is to promote a systems approach in designing, purchasing, installing, and managing boilers, steam distribution systems, and steam applications. For any end-user of steam, Steam Challenge provides credible resources to help improve steam systems, enhancing process operation and reducing fuel costs.

Steam Challenge is co-managed by the U.S. Department of Energy (DOE) and the Alliance to Save Energy, a national non-profit working on energy issues. The program is directed by a group of industrial end users, equipment suppliers, and organizations involved in the steam marketplace, acting together to promote the comprehensive upgrade of industrial steam systems. These are listed at left.

Optimization of industrial steam systems represents one of the largest non-process, industrial energy opportunities, with improvements of 30% readily achievable in typical plants through the introduction of a best practice approach. Steam accounts for $25 billion per year of U.S. manufacturing energy costs and 201 million metric tons of carbon equivalent (MMTCE), representing 13% of total U.S. emissions and 40% of U.S. industrial emissions.

Lack of unbiased information has been a primary barrier to realizing substantial improvements in efficiency, reliability, productivity, and safety. Often, plant operators may not have the resources to devote to better system management.

Steam Challenge Provides:

- Technical resources and assistance
- Lists of commercial training opportunities
- Case studies
- Lists of equipment providers
- Information to make the case on improving steam system management

How Companies Can Become Involved:

- Implement steam system projects
- Participate in or sponsor workshops to raise awareness of efficiency opportunities
- Submit data for a case study
- Use Steam Challenge documents and literature for their own clients and workshops

*Contact the Steam Challenge by phone at (800) 862-2086, or e-mail at steamline@energy.wsu.edu. Visit the Web site at www.oit.doe.gov/steam.*

# Steam System Optimization

*By Bob Aegerter, Equistar Chemicals, L.P.*

*This article is condensed from a technical paper presented at the 1998 Industrial Energy Technology Conference Steam Session. For the full paper, call (800) 862-2086.*

Using today's energy costs, the incremental cost of generating 1,000 lb./hr. of steam is typically $25,000–$35,000/year. This article explores numerous opportunities that may exist in your plant to save several thousand pounds per hour of steam for little or no cost. After several of these projects are implemented, the total savings can be significant.

## Develop a Steam Balance

To be able to optimize the steam system, you must understand the system. Developing an accurate steam balance of actual operating conditions is an excellent tool for understanding your steam system. Special attention should be made to accurately measure steam flows through steam let down stations and atmospheric vents for both summer and winter operating conditions.

## Balance Steam Excess or Deficit

Typically, a plant will either vent excess low-pressure steam or let down steam to meet low- pressure steam demand. If your plant is large and has several operating areas with independent steam systems, some areas may have an excess of low-pressure steam and other areas may have a deficit. To optimize a steam system, the plant must be integrated as much as possible so that one operating area's excess steam can eliminate the deficit of steam in another area. Reducing steam costs should be a continuous process of eliminating sources of excess low-pressure steam until a steam deficit exists and then implementing heat recovery projects to create a condition of excess low-pressure steam. Use the steam balance as the blueprint to coordinate projects, so large amounts of steam are never vented.

## Eliminate Excess Steam

Steam is vented from a pressure control valve when the amount of steam entering the header exceeds the amount of steam required to maintain the pressure controller's set point. A better solution than utilizing excess steam, which costs less and usually yields better savings, is to eliminate or reduce steam entering the steam header. A steam balance is an excellent tool to identify the steam sources. To eliminate excess steam, a plant can:

Shut down turbines. The easiest solution to eliminate excess steam is shutting down steam turbines that exhaust into the header and start up the motor-driven spare equipment. Often, this is enough to eliminate the venting. Shutting down steam turbines may not be the most cost-effective solution because an electric motor is now being operated. If excess steam can be eliminated without shutting down steam turbines, other solutions should be pursued. If the plant's electrical rate schedule includes heavy penalties to creating new peak demands, consider setting new electrical peak demands when turbines are shut down and motors started up.

Check leaking valves. To eliminate the excess steam condition, all sources of steam that contribute to the excess steam condition must be identified. The surplus steam may be from a higher-pressure steam header. One of the best places to look is steam let down control valves. If a let down control valve is open from a higher-pressure header and steam is being vented at a lower pressure level, steam is at excess at the higher steam pressure level. Sources of steam supplying the higher-pressure header must be investigated. If the steam let down control valves are closed and steam is being vented, the let down valves may be leaking, contributing to the excess steam.

The easiest way to determine a valve leak is to isolate the control valve and then observe the steam vent to see if the vent flow decreases. Replacing a leaking valve with an ANSI class V control valve can be justified over repairing a standard shut-off valve. Class V control valves seat much tighter and will have a positive seat much longer than standard control valves.

Steam traps that discharge into a steam header should be checked for proper operation. Badly leaking steam traps can over pressure a steam header.

Examine turbines. If let down valves are not contributing to the excess steam problem, steam turbines exhausting into that header should be examined. Hand valve positions on steam turbines should be initially examined. Typically, hand valves are opened up when the turbine is new and left open. Operating a steam turbine with hand valves open when additional horsepower is not needed causes the turbine to use higher steam flows than required. Open valves should be closed while

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Don Meadows, TAPPI Journal

*Many low-cost opportunities exist in your plant for steam system savings.*

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checking the turbine's speed. If the turbine maintains operating speed after hand valves are closed, the valves should remain closed. Hand valves should be operated in either fully open or fully closed positions. They are not meant for throttling steam.

Upgrade turbines. If hand valves are closed, check the nozzle block pressure. If there is a pressure drop across the governor valve of more than 10% of the steam inlet pressure, the turbine is over designed and could be rerated to operate more efficiently. Usually, this requires installing a new nozzle block. Rerating a steam turbine is relatively inexpensive and can be justified if the turbine is causing 1,000 lb./hr. of steam to vent to the atmosphere. Work with the steam turbine's manufacturer to obtain a proper rerate.

Although more expensive than rerating an existing turbine, it may be necessary to replace a steam turbine with a more efficient turbine or an electric motor driver to obtain the required steam flow reduction. When replacing a steam turbine, efficiency should be the prime concern. Typically, single-stage steam turbines operate most efficiently in the 5,000-6,000 rpm range. Most rotating equipment operates at either 1,800 rpm or 3,600 rpm. To get the desired additional turbine efficiency, it may be necessary to speed the turbine up with a gearbox. The additional cost of purchasing and installing the gearbox can be justified by the reduced steam flow through the turbine.

Another option to replacing a steam turbine that drives a fan or horizontally split case pump is extending the shaft on both ends of the driven equipment and having a motor driver and a steam turbine installed on opposite ends of the driven equipment. Either the motor or the turbine can easily be selected as the main driver by increasing or decreasing the speed of the steam turbine above or below the synchronous speed of the motor.

Vary header pressures. Varying steam header pressures can affect the steam rate through turbines. To lower turbine steam rates, either the inlet steam pressure can be increased or the exhaust pressure decreased. Lowering exhaust pressure will have more impact on turbine steam rates than raising the inlet pressure. The same technique can be used to obtain more horsepower from a steam turbine that has a fully open governor valve. Varying steam header pressures can also help transport steam between battery limits, which can help eliminate excess steam conditions.

Optimize deaerator operation. If it is not possible to eliminate excess low-pressure steam, then effectively utilizing the steam is the next best alternative. Your boiler area's deaerator offers a low-cost opportunity to recover excess low-pressure steam. If your deaerator is rated for a much higher pressure than it is operating, the deaerator pressure can be increased to absorb more steam. The resulting hotter boiler feed water reduces the amount of fuel required in the boilers and increases the amount of steam generated in waste heat boilers.

## Eliminate Steam Deficits

If steam is constantly being let down to meet the demands of the low-pressure steam header, then steam header demands should be reduced. Condensate and steam leaks should be repaired soon after they are detected because they can grow significantly larger in a very short time. If the leak cannot be isolated, several companies specialize in stopping steam leaks. Also, to reduce steam deficits:

Test traps. The plant's steam trap testing and repair program should be reviewed to determine its effectiveness. Ask:

- How frequently are steam traps tested?
- What is the method of testing?
- What is the steam trap failure rate?
- What method is used to repair or replace the steam traps?
- How long does it take after the faulty trap has been detected before it is replaced?

Standardizing on a specific trap that functions well in your plant, maintaining a good steam trap testing program, and repairing faulty steam traps soon after they are identified will minimize your steam trap energy costs.

Use correct amount of steam. Using the correct amount of steam for the required duty of equipment can significantly reduce steam use. Using the plant steam balance and plant design information, compare actual versus plant design steam use for all major steam users. Large discrepancies in steam use that cannot be accounted for by changes in plant operation suggest savings opportunities.

Most plants can control steam flow with a flare steam control monitor. This monitor uses an infrared detector to determine the amount of smoking at the flare tip and adjusts the steam flow to the flare to eliminate the smoking. Flare steam control monitors can usually be economically justified.

Insulate. Proper insulation of piping and equipment should never be overlooked to reduce the steam demand. Often flanges, control valves, steam turbines, man ways, sections of piping, heads on vessels, etc. are uninsulated. If steam is in demand at the steam pressure level of the uninsulated piping and equipment, the piping and equipment should be insulated. Conduct a survey of the condensate and steam system. Also conduct a study of all insulated high-temperature piping that has been in service for numerous years. It may be economically justifiable to repair damaged insulation or to add an additional layer of insulation.

## Recover Waste Heat

If all of your steam users are efficiently using steam, then waste heat recovery opportunities need to be explored. Compare the duties and temperature profiles on services cooled by air or water to services heated by steam. If the profiles compare favorably, consider projects to recover waste heat energy.

One excellent heat sink for waste heat recovery is deaerator make-up water. When the deaerator make-up water is preheated, the deaerator's steam demand will be reduced.

If, after reducing the demand on all steam users and implementing all economically attractive waste heat recovery projects, steam is still being let down to meet the demands of a low-pressure steam header, consider installing steam turbine drivers to

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## Steam System Optimization

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replace electric motor drivers. Again, steam turbine efficiency needs to be a prime concern.

### Add Flexibility

Steam systems are dynamic. Changes in the process can change the amount of steam that is venting to the atmosphere and being let down between pressure levels. Consider the following to add flexibility to your steam system:

- Identify steam turbines and motor drivers that can be started up or shut down to minimize steam vents and let down flows.
- Adjust steam header pressures to allow steam to be transported to other locations or to reduce the steam flow through turbines.
- Vary deaerator pressure slowly to eliminate steam venting but avoid excessive steam being let down.

### Optimize Steam Boilers

Repairing steam leaks and insulating equipment is also important at your steam boilers. Since boiler steam pressure and temperature levels are the highest in the plant, these measures will pay out quickly.

Also, repair air leaks around boilers. On negative draft boilers, air leaks waste fuel and cause refractory damage and erroneous excess oxygen readings. On positive draft boilers, air leaks waste fuel and can cause personal injury. Some fan and boiler capacity is also lost with air leaks.

Repair of damaged refractory can save energy because hot spots on the outer shell of the boiler result in heat loss to the atmosphere and reduced boiler efficiency. Refractory damage can also lead to mechanical damage to the boiler and possible personal injury.

Boilers need to be excess oxygen controlled. Oxygen analyzers should be calibrated and the fuel/air ratio controller tuned. Control boiler excess oxygen levels at the boiler manufacturer's recommendations.

*Contact Bob Aegerter at (815) 942-7390; e-mail to Robert.Aegerter@Equistarchem.com.*

# Boiler Efficiency vs. Steam Quality: The Challenge of Creating Quality Steam Using Existing Boiler Efficiencies

*By Glenn Hahn, Technology Manager, Spirax Sarco, Inc., Allentown, PA*

*This article is condensed from a technical paper/video presentation at the 1998 Industrial Energy Technology Conference Steam Session. For the full paper, call (800) 862-2086.*


*Steam quality is affected by water movement during different boiler operating situations.*

A boiler works under pressure, and it is not possible to see what is happening inside of it. The terms "wet steam" and "carry over" are every day idioms in the steam industry, yet very few people have ever seen these phenomena, and the actual water movement inside a boiler has remained highly speculative. This article illustrates the effects of steam quality vs. boiling efficiency during different boiler and steam system demands. The four different operating situations described below can affect steam quality.

### Case 1: On/Off Boiler Feed

Simply stated, boilers operate using a hot heat transfer surface covered with water. Steam bubbles produced at the transfer surface rise through the water and enter the steam system. Higher pressure at the heat transfer surface than at the water's surface causes steam bubbles to either a) leave the boiler slightly superheated, or b) cool to the saturation temperature of the water as they rise through the water. Under normal conditions, the steam bubbles tend to cool to saturation temperature as they rise through the water.

Feed water enters the boiler between the heat transfer surface and the surface of the boiling water. Although preheated, the feed water is still colder than the water in the boiler, creating a cold layer within the boiler water. Steam bubbles rise through this cold layer; they cool and some of the steam condenses. This causes two serious problems.

First, steam bubbles leave the water's surface and enter the steam system containing water mist. If a large amount of feed water enters the boiler, the steam space above the water level becomes foggy. This fog and the low-quality steam that results continue until the water in the boiler becomes reasonably isothermal.

Second, this large amount of cooler water slows the rate of steam production until the water reaches saturation temperature.

These problems are preventable by using continuous boiler feed rather than on/off boiler feed. A modulating feed adds water at a very low rate, which keeps the boiler water relatively isothermal and prevents clouding.

### Case 2: Reduced Operating Pressure

"Operate the boiler at its maximum design pressure," say the boiler designers. Too often, this rule is not followed when energy cost reductions are needed. During low steam demand, or when all the use points require pressure reduction stations, boilers are often operated at substantially less than design pressure. While, in some boilers, operation at lower pressure can slightly increase energy efficiency, it also reduces steam quality.

#### Lower Pressure Increases Entrainment

Water entrainment occurs as steam bubbles break through the final water layer into

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the steam space. The bubble's initial burst produces a rush of high-velocity steam that carries a small amount of water into the steam space. Additionally, the loss of the steam bubble from the water surface creates a crater and splashing, and water droplets are easily entrained in the rising steam.

Low-pressure operation requires a larger volume of steam to carry heat energy. This produces more and larger steam bubbles, which creates greater turbulence on the water surface. Higher vapor velocity from low-pressure operation combined with the turbulence tends to carry water droplets into the steam system.

The solution is to operate the boiler at its maximum design pressure and use pressure-reducing valves where required.

## Case 3: Rapidly Fluctuating Demand

In most industrial steam systems, steam demand fluctuates widely and can seriously affect steam quality. A rapid, short-term steam demand increase of only 15% can cause high entrainment of water in the boiler. Such demand increases occur quite frequently in industrial plants when steam valves are opened all at once.

When a steam valve opens, two problems occur in the boiler. First, steam pressure drops rapidly and causes entrainment. Second, the interface between water and steam rises. A phenomenon known as "swell" results as the water level rises and is sucked into the steam line. This boiler water loss can shut down the boiler; in the meantime, the steam lines fill with water.

### Compact Boilers Can Magnify the Problem

Modern boilers are highly efficient and very compact. While this design has advantages, these boilers have little steam space to dampen changes in steam demand. If steam use increases only slightly, the pressure in the boiler can drop significantly, increasing entrainment.

### High Entrainment Fools Low Water-Level Alarm

Sometimes, steam demand increases are so disruptive that the boiler life and steam quality suffers. The external indicator might show a satisfactory water level; yet the actual level of the water/steam mixture in the boiler may be filling the steam space, and water may be pouring into the steam lines. Tubes can overheat and can be damaged by the time the external detector identifies a low water level and shuts down the boiler. The plant will be without steam until the boiler is restarted.

The key to reducing this cause of poor steam quality is to prevent rapid increases in steam demand. Modern computerized control systems using a PLC or DCS can accommodate this solution.

## Case 4: High TDS

High or fluctuating total dissolved solids (TDS) in boiler water increases tube corrosion and/or fouling. The table below shows examples of additional operating costs that can result from poor quality feed water. TDS results in low heat transfer, reduced boiler capacity and efficiency, and shortened tube life. It can also affect steam quality.

Increased TDS in the boiler water increases foam production on the water's surface. This foam is produced by, and is easily entrained by, the steam rising out of the water. It can be drawn into the steam system, depleting the boiler of water before the level detector can identify the problem while filling the steam lines with corrosive water.

The solution is to keep TDS at least as low as that recommended by the boiler manufacturer. There is no definitive evidence indicating a steam quality difference between on/off or modulating blowdown to control TDS. However, given the adverse effect of rapid and intermittent inflows of make-up water, modulated blowdown is preferred.

## Conclusion

Steam quality—a measurement of the amount of water entrained in the steam—depends not on the efficiency of the boiler but on the ability of the steam to separate from boiling water, without carrying liquid water particles over the range of boiler operations. To prevent poor quality steam:

A. Control steam usage to ensure that steam demand does not exceed boiler capacity.
B. Control steam usage change to ensure rapid changes in steam demand will not reduce steam quality.
C. To affect A and B above, use modulating instead of on/off valves at steam use points.
D. Add boiler feed water with modulating, not on/off, controls.
E. Use TDS controls rather than time-based blowdown.
F. Operate the boiler near its maximum design pressure.

When these recommendations are not followed, reductions in steam quality can be dramatic. Low steam quality can damage steam distribution equipment, control valves, and heat exchangers by water hammer, erosion, and corrosion. This results in shortened equipment service life, steam loss, low operating efficiency, and even safety problems.

*Contact Glenn Hahn at (800) 624-1817 x2099 with questions or for information about the video that accompanies this paper.*

### Additional Operating Costs from Poor-Quality Feed Water

Steam flow 100,000 lb/hr and feed water temperature 230°F in all cases.

| | Steam Temperature: Saturated/ Steam Pressure: 300 psig | | Steam Temperature: 850°F/ Steam Pressure: 850 psig | |
|---|---|---|---|---|
| Blowdown, % | 2 | 10 | 2 | 10 |
| Boiler duty, MM Btu/hr | 100.8 | 102.4 | 123.1 | 125.7 |
| Heat input, MM Btu/hr | 121.5 | 123.4 | 148.4 | 151.5 |
| Flash steam recovery, % | 20 | | 33 | |
| Additional cost per year | – | $36,840 | – | $49,850 |

Same efficiency of 83% HHV assummed in all cases.

Source: V. Ganapathy, "Examining the Costs of Boiler Operation," *Chemical Online.*

## Steam System Improvement: A Case Study

*By Ven V. Venkatesan, Director of Engineering Services and Novi Leigh, Steam Systems Engineer, Armstrong Service, Inc., Orlando, Florida*

*This article summarizes a case study presented at the 1998 Industrial Energy Technology Conference Steam Session. For the full paper, call (800) 860-2086.*

Steam plays a pivotal role in industrial plants because of its availability and advantageous properties for use in heating processes and power cycles. Therefore, it is widely used as a heating medium. Steam systems consist of components such as the steam generator (boiler), steam distribution lines, process heating equipment, steam turbines, pressure reducing valves, condensate return lines, and steam traps.

A thorough review of a major petroleum refinery system confirmed energy savings potential in its boiler, steam distribution, and condensate systems. This article highlights eight energy-saving opportunities identified at the site, and the measures taken to realize these savings.

### Replace All Defective Steam Traps

Steam traps remove condensate from the steam distribution system. They also remove air and other non-condensable gases that cause corrosion and impede heat transfer. Misapplication, improper sizing, and piping conditions are the common causes of failed steam traps.

Selection of steam traps depends on the conditions of the system handled, such as condensate load, back pressure, air and non-condensable gas content, and process application like constant pressure or modulating. The wrong steam trap in an application can be as disastrous as a failed steam trap in an open or closed position; both errors lead to energy waste. Undersized steam traps will not remove condensate, which causes flooding of the equipment and can produce damaging water hammer. Oversized traps may result in wasted live steam.

Steam trap applications can be divided into three categories: 1) line drip service, 2) tracer service, and 3) process service. There are over 3,000 steam traps at the site. Most of them are for drip and tracer application, with a small portion for coils and heat exchangers. At this site, 60% of the steam traps are in service, and 23% of those were found defective in blow-through, cold-plugged, or leakage. A diligent maintenance process is required to capture and sustain savings from steam traps.

### Optimize Combustion in Boilers

Optimum boiler combustion occurs when excess air is supplied at the correct amount so that fuel is completely burned and flue gas heat loss is minimized. Optimum excess air depends on the type of fuel and burner design. In this plant, combustion air is supplied either from a forced draft (FD) fan or by the hot exhaust gases from a gas turbine. Analysis of operating data shows the boilers operate at 30% to 35% excess air levels. In general, gas burners are designed for excess air levels between 5% and 10%.

An eight-step action plan was recommended to optimize excess air levels at the boilers:

1. Stabilize boiler at its normal operating load.
2. Verify present combustion conditions with a portable flue gas analyzer.
3. If combustibles and CO are not present, reduce FD air in smaller steps.
4. Verify combustion conditions again after 10 minutes of stable boiler condition.
5. If combustibles are not present, repeat steps 3 and 4 until oxygen level in the stack gas reaches around 2% to 3%.
6. Reset the oxygen trimming system in the fuel-air ratio controller of the boiler in conjunction with the combustibles/CO analyzer.
7. Repeat steps for other boilers.
8. Nominate utility operating personnel to Efficient Boiler Operation seminars.

A decision was also made to install a new combustibles analyzer and hook up oxygen trimming with the existing fuel-air ratio controller.

*Review of a refinery's boiler, steam distribution, and condensate systems revealed potential energy savings of $1 million+.*

### Eliminate Back Pressure in Condensate Line to Enhance Condensate Recovery

Collection and return of clean condensate streams and utilization of available heat are practical and economical energy conservation opportunities. Benefits include reductions in make-up water and water treatment costs, boiler blowdown resulting in direct fuel savings, steam requirement for boiler feed water deaeration, raw water costs, and sewage discharge costs.

The overall condensate recovery at the site is between 55% and 60% of steam generation. High back pressure in the return line causes condensate from steam traps to drain into the atmosphere at some locations. A major reason for this is steam passing through failed traps. Insufficient sizing and orientation of condensate return lines also contribute to back pressure.

Back pressure in the return header should be corrected to enhance condensate recovery. Enhancing condensate recovery involves additional time and effort. Nonetheless, this could potentially improve condensate recovery to over 80%.

### Install Low-pressure Economizer

The largest energy loss in every combustion process is flue gas heat. Reducing flue gas temperature improves boiler efficiency. As a rule, every 40°F reduction in stack temperature increases boiler efficiency by 1%. Installing waste heat recovery equipment in a natural gas-fired boiler can improve its efficiency when the stack temperature exceeds 250°F. The limiting factor to flue gas heat recovery is corrosion if oxides of sulfur condense as flue gas cools. This occurs only when the fuel contains sulfur.

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An economizer can recover the heat from flue gas to preheat the boiler feed water. Generally, every 11°F temperature rise in the feed water increases boiler efficiency by 1%.

The utility boilers at the site are designed with economizers. Boilers are gas-fired with little or no sulfur content in the fuel. Combustion air is supplied from gas turbine exhausts, and flue gas exits the boilers at approximately 310°F-320°F. Flue gas cannot be cooled below 310°F because boiler feed water temperature at the deaerators is maintained between 275°F-285°F. This restricts heat recovery despite firing with low-sulfur fuel.

Installing a low-pressure economizer in the boiler flue gas duct would connect the existing economizer and chimney. The flue gas temperature would be 230°F. This method of heat recovery is a proven practice at many sites.

### Install Vent Condensers

Boiler feed water must be free of air and other dissolved gases that harm boiler tubes. Gases are removed in the deaerator where water is sprayed and scrubbed with steam. Steam and the non-condensable gases are vented from the deaerator. However, this steam contains a lot of recoverable heat.

At this plant, steam is vented in excess of the normal levels at deaerators and some condensate receiving tanks. Deaerator pressure is normally maintained at 7–10 psig because at pressures above 7 psig, the escaping vapors will be mostly steam.

A vent condenser installed at the top of the deaerator can capture part of the heat from the escaping steam, while allowing the non-condensable gases to escape. The recovered heat can be used for heating the boiler feed water in the vent condenser. The proposed condenser would be cooled by incoming, fresh demineralized water before entering the deaerator.

### Supply Low-pressure Steam Instead of Medium-pressure Steam to Jetty Services

Steam in the plant's Jetty area is used for space heating, tracing, and line purging. Steam is supplied at 65 psig by letting down through a pressure-reducing valve (PRV) from the 225-psig, medium-pressure steam header. Steam users at the Jetty area are not critical and can tolerate marginal variations in steam pressure. Often, low-pressure steam is in excess and is rejected to atmosphere.

A jump-over connection could be made from the low-pressure steam header to the medium-pressure steam line leading to Jetty services. This would also keep the PRV bypassed or removed. The medium-pressure steam line at the upstream of the jump-over connection should be isolated, preferably with a spaded valve.

Implementing this recommendation will reduce this plant's energy loss from low-pressure steam condensing and will avoid letting down steam from medium to intermediate pressure.

### Automatic Switch-over between Motor and Steam Turbine Drives

At this site, steam turbine exhaust cannot meet the demand of medium-pressure steam that requires steam let down from higher to lower pressure through a PRV.

Most of the plant's rotating equipment has turbine drives to supply low-pressure steam and motor drives for operating flexibility. This flexibility optimizes costs by utilizing the steam's pressure energy to drive the compressors, pumps, and blowers. Pressure-reducing valves between the three pressure levels meet the demand of lower-pressure steam. Excess low-pressure steam is condensed to avoid steam venting and to save feed water. The steam condensing operation and letting down steam from higher to lower pressure are inefficient operations of the system.

Recommendations to minimize steam flow through pressure reducing valves and condensing of excess steam include:

- Listing all steam turbine driven equipment with present steam consumption rate at normal operating conditions.
- Measuring electricity consumption in the same equipment when driven by electric motor.
- Preparing a priority list for switch-over.
- Developing software that can combine the on-line DCS data and priority list to advise the utility operator for switch-over based on PRV steam flows and excess low-pressure steam at specified steam and electricity cost.

A systematic switch-over between turbine and motor drives will reduce steam flows through PRVs and excess condensing steam and could result in an 80% reduction in PRV steam flow.

### Fix All Identified Steam Leaks

Steam leaks contribute to direct heat loss in the steam distribution system and are the most obvious to fix immediately. Steam leaks increase boiler load and make-up water consumption. A survey identified all steam leaks and categorized them as leaks to be fixed offline or online.

### Conclusion

This refinery could save $1,110,000 in annual steam costs by implementing the eight recommendations. The table at left summarizes the recommendations. The measures require no major process modification. Some require no investment and can be implemented through better day-to-day operation or a periodic maintenance program. Those that require new equipment can be done during the plant turnaround. Optimizing the steam system will also reduce carbon emission by 5 million pounds annually.

*Contact the authors at (407) 370-3301; e-mail at VeeVen@aol.com or NLeigh6200@aol.com.*

### Steam System Savings Recommendations

| Recommendations | Estimated Savings ($/year) | Payback (Approximate) |
|---|---|---|
| 1. Replace all identified defective steam traps. | 284,600 | 19 months |
| 2. Optimize combustion in boilers. | 94,500 | 10 months |
| 3. Enhance condensate recovery by eliminating sources of backpressure in condensate return. | 105,900 | 14 months |
| 4. Install low pressure economizer in boiler flue gas ducts. | 166,000 | 24 months |
| 5. Install vent condenser for deaerator. | 43,200 | 19 months |
| 6. Supply LP steam instead of MP steam to Jetty service. | 41,100 | 6 months |
| 7. Optimize steam balance by systematic switch-over between motor and steam turbine drives. | 28,200 | 12 months |
| 8. Fix all identified steam leaks. | 346,500 | 3 months |
| Total estimated savings | 1,110,000 | 12.6 months |

| | |
|---|---|
| Estimated annual steam cost | $8.6 million |
| Reduction in steam cost by implementing all recommendations | 12.90% |
| Reduction in environment emission of Total Carbon | 5 million lbs/year |

## 3E Plus™ Saving Money through Improved Industrial Insulation

*An interview with Bill Brayman, Technical Chairman, Commercial/Industrial Insulation Committee, North American Insulation Manufacturers Association (NAIMA), Alexandria, Virginia*

Please describe your role at NAIMA?

I am the technical chairman of the committee on commercial/industrial insulation. The committee is charged with supplying technical back up for the insulation industry and members of NAIMA.

Why did you become involved in DOE's Steam Challenge?

The insulation industry recognized that a problem existed with people not being able to identify Btu loss in steam lines, insulated or not. Nobody could count it. So, we joined the Steam Challenge to help disseminate conservation materials/tools on steam piping to help industry save money and energy. Through our involvement, we hope to equip people with the ability to translate the performance of their insulation into dollars—that is what gets everybody's attention.

You mentioned conservation tools. Can you give an example of one?

There is a software tool called 3E Plus™ that provides industry with the performance, Btu saving, and payback data needed to determine the most appropriate insulation thickness for a company's application. It was built with academia and DOE. In a typical plant, an employee has no idea what dollars are radiating off the pipes. 3E Plus™ helps users understand this loss in Btus, dollars, and greenhouse gas emissions. Version 2.12, the one that is available now, is a DOS program and can not be used on a network. To better address the needs of the industry, we are developing a new version C3.0.

Can you explain how the soon-to-be-released upgraded version of 3E Plus™ will differ from the current 2.12 version?

The new version:

- takes into account metrification of the construction industry—a high-priority issue with the users.
- addresses different terminology for pipes. The new program will correlate the European names with the American ones.
- gives the cost difference and savings to run one foot of uninsulated pipe versus insulated pipe, after inputting fuel cost, fuel type, and annual operating hours of the pipe. It will also show the reduction in $CO_2$, $NO_x$ and CE (carbon equivalency) for an insulated versus uninsulated pipe, which was not possible with version 2.12. The previous version just showed the Btu cost of running uninsulated pipes.
- addresses different types of pipes, such as stainless steel and copper.
- runs on Windows 95 and Windows NT.

*William Pitkin (L), Executive VP of the National Insulation Association (NIA) presents the NIA 1998 Industrial Energy Savings Award to Robert Chango (R), VP Operations at Bethlehem Steel, Burns Harbor. Also present, Denise Swink, Deputy Assistant Secretary, DOE's Office of Industrial Technologies.*

Is 3E Plus™ difficult to use?

No, one just needs to fill in the blanks. What makes it very user friendly is the defaults that are programmed into the software. If a user does not have the answer to one of the questions, he or she can go with the default data or use the help comments at the bottom of the screen.

Can you give an example of companies successfully using 3E Plus™?

Georgia-Pacific and Bethlehem Steel's Burns Harbor division have both benefitted from the use of 3E Plus™. In the interest of time, I will just go into the Burns Harbor example. They were awarded the National Insulation Association's 1998 Industrial Energy Savings Award for outstanding energy conservation efforts, one of which involved thermal insulation. The award was presented at DOE's energy efficiency symposium and exposition in Washington, D.C.

What exactly did they do?

They covered 1,040 feet of a 14-inch pipe with 3.5 inches of calcium silicate pipe insulation and aluminum jacket. The heat loss for the pipe was 5,660 Btus per foot per hour. After adding the insulation, the Btus were reduced by 95.5%. Now they are losing only 253 Btus per foot per hour from the pipe.

Burns Harbor would have spent $353 a year per foot of pipe to operate with no insulation on a steam pipe. They saved, by use of insulation, $337.50 per foot per year. The insulated 1,040 feet of the 14-inch pipe is also saving 6,617 lbs of $CO_2$ per foot per year, 1,805 lbs of CE per foot per year, and 14.2 lbs of $NO_x$ per foot per year. For the entire distribution piping in the plant, Burns Harbor is saving over 2.65 trillion Btus annually through insulation!

Why did they decide to do this?

They have an active energy conservation program and were knowledgeable of the heat loss on the uninsulated pipe. So, using insulation was really a no-brainer. We, meaning NAIMA, inventoried the pipes and quantified, using 3E Plus™, how much was being saved. Bethlehem Steel knew they were saving money and energy, but didn't know how much. The software program confirmed what Bethlehem Steel was thinking in terms of the savings. The payback works out to less than 6 months.

When will the new version be released?

Version 3.0 will be available later this summer. People can access a copy of 3E Plus™ through the Web site at www.oit.doe.gov/tools.shtml#software. Otherwise, people can call (800) 862-2086 for information on how to obtain a copy.