Guidebook to Energy-Related Resources for the Chemical Industry
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Coordinated by:

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1. Introduction

DEFINITION OF CHEMICAL PROCESSING
Chemical processing is defined as converting raw materials or feedstock into higher value chemicals or other related products. The chemical industry, which includes all chemicals from commodities (e.g. ethylene and ammonia) to finished products like cosmetics and pharmaceuticals, is part of the manufacturing sector. The conversion process utilizes significant amounts of labor, machinery, and energy. In addition, it relies increasingly on scientific knowledge to both improve quality and safety, and to reduce production costs.

An integral part of the U.S. economy since the 17th century, the modern chemical industry produces more than 70,000 diverse products. Indeed, few goods today are manufactured without some involvement with the chemical industry. Nearly 24% of all chemicals produced are used as feedstock in other chemical manufacturing processes, and nearly 30% of the total production yield is purchased as raw materials by the rest of the manufacturing sector, according to the U.S. Department of Energy.

ENERGY CONSUMPTION
The chemical industry is the second most energy-intensive enterprise in the United States, accounting for over 6500 trillion Btus (TBtu) of energy use in 2002, the most recent year for which statistics are available. This represents one-third of the total industrial energy used in America, according to the American Chemistry Council.

Chemical processing requires large amounts of energy to convert raw materials into finished products, which makes the industry particularly vulnerable to fluctuations in energy prices. Chemical manufacturing is the largest consumer of natural gas in the United States, requiring more than 10% of the total amount used domestically, as reported by the U.S. Department of Energy. The challenge faced by chemical manufacturers is how best to identify possible sources of improvement and implement changes that can take place quickly, while providing the most benefit with the smallest capital investment.

PURPOSE OF THIS PUBLICATION
This Guidebook is an excerpt of a larger publication, Energy-Related Best Practices: A Sourcebook for the Chemical Industry, which was funded by a grant from the Iowa Energy Center. The purpose of that publication is to introduce chemical processors to money-saving best practices as well as to identify resources that can be of assistance in helping chemical processors manage their energy costs.

The Sourcebook contains eight chapters: Introduction; Energy Management; Understanding the Energy Cost Structure; Process Heating Systems; Process Steam Systems; Chillers; Pumps and Motors; and Available Resources. Each chapter contains best practices with explanations of the logic behind those best practices. The various sections in each chapter contain references that identify resources for chemical
processors. All of the resources and best practices are consolidated and reprinted here for easy dissemination to the chemical Industry.

# Resources

## BEST PRACTICES

## PROCESS HEAT BEST PRACTICES

General Process Heating Best Practice Information

<table>
<thead>
<tr>
<th>Process Heating Component</th>
<th>Energy Saving Method</th>
<th>Energy Saving Potential (% of current use)</th>
<th>Typical Implementation Period</th>
<th>Typical Payback</th>
<th>Example Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Heating Generation</td>
<td>Efficient combustion (burners) and operation of other heat generating equipment</td>
<td>5%-25%</td>
<td>1 week to 2 months</td>
<td>1 to 6 months</td>
<td>Maintain minimum required free oxygen (typically 1%-3%) in combustion products from burners for fuel-fired process heating equipment. Control air-fuel ration to eliminate formation of excess carbon monoxide (CO), typically more than 30-50 ppm, or unburned hydrocarbons. Eliminate or minimize air leakage into the direct-fired furnaces or ovens.</td>
</tr>
<tr>
<td>2. Heat Transfer</td>
<td>Design, operation, and maintenance of furnaces and heating systems to increase heat transfer from heat source to process or load</td>
<td>5%-15%</td>
<td>3 months to 1 year</td>
<td>6 months to 1 year</td>
<td>Select burners and design furnaces that allow use of high convection or radiation in processes and loads. Clean heat transfer surfaces frequently in indirectly heated systems, such as steam coils, radiant tubes, and electrical elements. Replace indirectly heated systems, such as radiant tubes, and enclosed electrical heating elements, where possible.</td>
</tr>
<tr>
<td>3. Heat Containment</td>
<td>Reduction of heat losses</td>
<td>2%-15%</td>
<td>4 week to 3 months</td>
<td>3 months to 1 year</td>
<td>Use adequate and optimum insulation for the equipment. Conduct regular repair and maintenance of insulation.</td>
</tr>
<tr>
<td>4. Heat Recovery</td>
<td>Flue gas heat recovery</td>
<td>10%-25%</td>
<td>3 to 6 months</td>
<td>6 months to 2 year</td>
<td>Preheat combustion air. Preheat and/or dry the charge load. Cascade heat from exhaust gases to the lower temperature process heating equipment.</td>
</tr>
<tr>
<td>5. Sensors and Controls</td>
<td>Improved process measurements, controls, and process equipment</td>
<td>5%-10%</td>
<td>1 to 10 week</td>
<td>1 to 6 months</td>
<td>Develop procedures for regular operations, calibration, and maintenance of process sensors (i.e. pressure, temperature, and flow) and controllers.</td>
</tr>
<tr>
<td>6. Process Models and Tools</td>
<td>Process models and design simulation to optimize equipment design and operations</td>
<td>5%-10%</td>
<td>2 weeks to 6 months</td>
<td>1 months to 2 year</td>
<td>Set appropriate operating temperatures for part load operations to avoid long “soak” or overheating.</td>
</tr>
<tr>
<td>7. Advance Materials</td>
<td>Reduction of nonproductive loads</td>
<td>10%-25%</td>
<td>2 weeks to 3 months</td>
<td>3 months to 2 year</td>
<td>Use improved materials, design, and applications of load support (fixtures, trays, baskets, etc.) and other material systems.</td>
</tr>
</tbody>
</table>
Best Practices—Reducing Exhaust Gas Losses

- Monitor and maintain the proper level of O₂ concentration, 2-3%, by operating at the correct air/fuel ratio for the burner.
- Wherever possible, use heat recovery of flue gas to preheat incoming combustion air.
- Eliminate or reduce all sources of undesired air infiltration into the furnace.
- Perform proper maintenance on a regular schedule to reduce soot and other deposits on heat transfer surfaces, thus ensuring efficient transfer of heat to the process.

Best Practices—Check Burner Air/Fuel Ratio

- Regularly monitor airflow rate or exhaust gas composition.
- Determine the optimum level of excess air for operating your equipment.
- Set combustion ratio controls to maintain that amount of excess air.
- Maintain excess air in the 10-20% range.
- Maintain a 2-3% O₂ concentration in exhaust gas.
- Maintain a CO concentration of no more than 350 ppm.

Best Practices—Preheating of Combustion Air

- Consider various options for recovering heat from flue gases.
- Rule of thumb for beginning analysis: Processes operating at or above 1600°F are good candidates for air preheating, while process operating near or below 1000°F may not be justified. Those operating within the range of 1000 to 1600°F may still be good candidates but should be considered on a case-by-case basis.

Best Practices—Reducing Air Infiltration into Furnace

- Use a draft (pressure) control system where possible to maintain a slightly positive pressure. The furnace pressure can be controlled using a damper on the combustion air blower or by installing a damper in the furnace exhaust stack.
- Minimize the draft (negative pressure) in an induced-draft system by reducing the openings through which cold air enters the furnace.
- Specify and use a forced-draft system with pressure control in future rebuilds or for new heaters.
- Check seals for leaks using a “smoke” device. Damaged seals will allow air to leak into the furnace and therefore, must be repaired or replaced.
- Perform regular inspections. Bi-annual checks are recommended.
Best Practices—Performing Proper Furnace Maintenance

• Keep heat transfer surfaces on indirect heat generation furnaces clean and free of deposits and soot.
• Ensure burner is operating properly and most efficiently within the limits set by controls and operators.
• Continuously inspect the furnace enclosure for any forms of deterioration or safety issues.

Best Practices—Optimize Generation Heat Transfer

• When economically feasible, select high-heat, transfer-rated equipment for retrofits and new installations.
• When contacting a vendor, select burners and/or have the vendor design furnaces that allow use of high convection or radiation in processes and loads.
• Replace indirectly heated systems and enclosed electrical heating elements where possible.

Best Practices—Optimize Heat Transfer Equipment Design

• Make certain new heat transfer equipment is properly designed for the specific operation, employing the exact parameters inherent to the operation. This will eliminate trapped air and increase the heat transfer rate.
• Make sure all heat transfer units and equipment are installed and operating according to mandated TEMA (Tubular Exchanger Manufacturer Association) and ASME (American Society of Mechanical Engineers) designations, requirements, and codes. More information can be found at the respective websites, www.tema.org and www.asme.org.
• Air or non-condensable entrainment is very problematic to steam heat exchanger equipment. For a more detailed explanation and best practices for removal, see Section 5.6.3.

Best Practices—Clean Heat Transfer Surfaces

• Examine flue-side heat transfer surfaces on a regularly scheduled interval; remove deposits and contaminants.
• Use a soot blower to automatically clean heat transfer surfaces if required.
• Use soot burnout practices for radiant tubes or muffles used in high-temperature furnaces.
• Use continuing agitation or other methods to avoid build-up of contaminants on heat-transfer surfaces.
• Heat-transfer surfaces in indirectly heated systems should be cleaned regularly. This includes process stream coils, radiant tubes, and electrical elements.
• If necessary, add a fouling factor when designing a new system or selecting new heat transfer equipment.
Best Practices—Concerns Using Water as Heat-Transfer Medium

- Examine the waterside of heat-transfer surfaces for scale; remove any deposits.
- If scale is present, consult a local water treatment specialist about modifying chemical additives.

Best Practices—Insulation for Heat Transfer Components

- Insulate all heat transfer units and ancillary components.

Best Practices—Maintenance and Servicing Considerations

- The design and installation of heat-exchange equipment must permit access to the heat-transfer area for cleaning.
- Use the correct type of heat exchanger for the job. A process that requires constant cleaning should use a heat exchanger that is easy to clean, using either chemical or mechanical means.

Best Practices—Reduce Containment Vessel Heat Losses

- Create a temperature profile of the furnace wall surface using readings from an infrared thermograph or other temperature-measuring instrument.
- Identify “hot-spots” with higher than average temperature and check sources of excessive heat loss (e.g., openings, cracks, damaged or missing insulation, etc.).
- If the average surface temperature exceeds 250°F, review the type and thickness of insulation; consult a furnace or insulation supplier to identify improvement opportunities.
- Use fiber insulation, replacing insulating bricks where possible.
- Always perform periodic maintenance of the insulation, inspecting for cracks and missing insulation; repair or replace as needed.

Best Practices—General Insulation Needs

- Use proper insulation on all exposed piping, fittings, fixtures, traps, and process use equipment. Use the proper type of insulation for the application. Safety issues, temperature, and ambient environment can affect the choice of insulating materials.
- Fiber insulation, which is less costly and easier to install, should be used wherever possible.
Best Practices—Reduce Radiation Losses from Openings

- Never allow an opening to be continuously ajar.
- Use and maintain proper seals to reduce or eliminate openings.
- Regularly inspect seals for cracks around components such as burners, feed pipes, and cooling tubes; repair as need.
- If closing or sealing doesn’t eliminate openings, install a “radiation shield” such as a metal plate or a “ceramic fiber” curtain to reduce direct radiation losses (such as in the case of sight glass openings in a boiler or reformer). A simple shield may reduce radiation losses by half.

Best Practices—Reduce Cooling Losses

- Reduce the amount of equipment that must be cooled by using more advanced, less heat sensitive materials, especially in retrofits and new installation.
- Properly insulate all parts cooled by a cooling medium.
- Always perform periodic maintenance of the insulation, inspecting for cracks and missing insulation, repairing and replacing as necessary.

Best Practice—Load Preheating

- Use hot furnace products or other waste heat from process streams to preheat incoming loads in a separate unit. This is especially applicable during retrofits or new installations.

Best Practices—Waste Heat Boiler Steam Generation

- The addition of waste heat boilers to any process heating system is encouraged, especially if additional steam capacity is required or would be beneficial. The boiler can use the waste heat in hot gases as well as liquids from the flue gas of process furnaces or from hot process streams to produce steam. The additional steam capacity maybe sufficient enough to shut down or reduce the load on existing high-energy consuming boilers.
- Check the steam demand schedule against the furnace-operating schedule, as steam from a waste heat boiler can be produced only when a source of waste heat is present.

Best Practice—Waste Heat Hot Water Generation

- Determine water quality requirements and where possible, use water from a direct contact water heater for one-time activities like general washing and sterilization. The slightly acidic water can also be used in chemical mixing tanks, certain aspects of grain mill operations, and general washing applications.
**Best Practices—Cascading Heat to Lower Temperature Operations**

- Review processes where heat is used at temperatures lower than the flue gas or other process stream temperatures. Evaluate appropriateness of applying cascading heat.
- Use flue gases or other high temperature process streams to lower temperature processes. This energy-saving method is most effective when the primary and secondary processes operate on similar schedules.

**Best Practices—Process Sensors and Controls**

- Develop procedures for regular operation, calibration, and maintenance of process sensors (e.g., pressure temperature and flow sensors and controls).
- For further information about controls, visit www.ashrae.org.

**Best Practices—Proper Maintenance**

- Follow the manufacturer’s suggested maintenance plan. If this is not possible, establish a regularly scheduled maintenance program that closely resembles the recommended plan.
- Assign a highly qualified person to maintain steam traps (may also supervise preventative maintenance, root cause analysis, purchasing, and equipment installation). Steam traps are a major source of heat loss and inefficiency for the chemical industry.
- Perform root cause analysis on failed parts to determine the impact of installation and placement. Determine the exact cause of failure; do not simply assume that the part failed due to non-preventative issues.
- Clean heat exchangers regularly; develop a schedule based on the level of fouling on surfaces.
- Ensure that water used for steam is properly treated.

**Best Practices—Proper Equipment Selection**

- Use the proper selection criteria when ordering from a manufacturer.
- Best practices for proper equipment selection vary, but steam equipment can be used as one example. The process furnace may produce 100 psi steam, but at the point where the equipment is installed the pressure may be 90 psi. Therefore, to ensure the most efficient operation, the device should be used at this rating and not at 100 psi.

**Best Practice—Low Pressure Separation**

- Decrease pressure as much as feasible in separation devices using electric vacuum pumps, thermo compressors, steam jets, and condensers. In turn, this will lower the heat input required for the process.
Best Practices—Proper Air Venting

- All heat transfer mechanisms should have air vents installed at the locations indicated by the manufacturer.
- Typical points of installation are close to the steam inlet or on the top portion of the unit.

PROCESS STEAM BEST PRACTICES

Best Practices—Determine Optimal Steam Pressure

- The boiler plant should produce steam at the lowest possible pressure level to meet the plant requirements.
- Provide a separate heat source for parts of processes that require high pressure steam or process heating fluid, thus minimizing the need to operate the entire plant at elevated pressures or temperatures.

Best Practices—Reducing Boiler Exhaust Gas Losses

- Monitor and maintain the proper level of O₂ concentration, 2-3%, by operating at the correct air/fuel ratio for the burner.
- Use heat recovery of flue gas where possible to preheat incoming combustion air.
- Eliminate or reduce all sources of undesired air infiltration into the furnace.
- Perform proper maintenance on a regular schedule to reduce soot and other deposits on heat transfer surfaces, thus ensuring efficient transfer of heat to the process.

Best Practices—Performing Proper Boiler Maintenance

- Ensure that heat transfer surfaces on indirect heat generation furnaces are clean and free of deposits and soot.
- Ensure burner is operating properly and most efficiently within the limits set by controls and operators.
- Continuously inspect the furnace enclosure for deterioration or safety problems.

Best Practices—Use of Heat Recovery

- The addition of waste heat boilers to any process heating system is encouraged, especially if additional steam capacity is required or would be beneficial. The boiler can use the waste heat in hot gases and/or liquids from the flue gas of process furnaces or from hot process streams to produce steam. The additional steam capacity maybe sufficient enough to shut down or reduce the load on existing high energy consuming boilers.
• Check the steam demand schedule against the furnace operating schedule, as steam from a waste heat boiler can only be produced when a source of waste heat is present.

**Best Practices—Reduce Blowdown Energy Losses**

• Whenever possible, improve water treatment mechanism to reduce the amount of total dissolved solids in the boiler feedwater, in turn reducing the frequency of blowdown.
• Install an automated blowdown system to optimize the interval and quantity of blowdowns, so the least amount of energy is wasted.
• Install a blowdown heat recovery device. This will generally include two methods of recovery, heat exchanger and flash steam generation.

**Best Practices—Boiler Heat Containment**

• Reduce containment vessel heat losses through the proper use of insulation and refractory.
• Reduce radiation losses from walls and openings.
• Eliminate losses imposed on the system by unnecessary or inefficient cooling.

**Best Practice—Eliminate Steam Leaks and Venting**

• Minimize all avoidable steam losses from leaks and/or venting.
• Continually inspect steam distribution and condensate return lines for leaks and repair as necessary.

**Best Practices—Proper Steam Line Materials and Installation**

• Materials used for steam and condensate systems should be specified and applied based on codes B31.1 and B31.1, as well as internal requirements for performance and reliability.
• All pipes or tubes should be welded, which minimizes leaks as the pipe expands and contracts during heating and cooling cycles. Welding also eliminates leaks from corrosive carbonic acid in the system, which is formed from carbon dioxide in the air and water.
• Screwed connections should be used to install equipment that requires frequent maintenance such as traps, valves, check valves and pipes smaller than two inches. Flanges are utilized in applications larger than two inches where maintenance or removal may be required.
• All steam supply and condensate return pipes should be properly supported, guided, and anchored, allowing for expansion of the pipes during temperature changes. A structure that is too tight can deform pipes and cause leaks.
**Best Practices—Ensure Steam Quality**

- Steam should be delivered to the end-use operation in the desired condition. Normally 100% saturate steam vapor is used.
- Always connect the branch line to the top of the main steam line. This will ensure dry, saturated steam to the process.
- Use proper drip-pocket steam traps, correct branch connections, and installation procedures.
- Install and maintain proper insulation on all steam and condensate return lines.
- Ensure proper pipe sizing is used to maintain correct velocities in steam line based on specifications of operation.
- Install and maintain coalescing mechanical separators where applicable.
- Implement the use of steam filters throughout the process steam system.

**Best Practices—Use Proper Drip Pocket Steam Trapping**

- Steam traps should be installed at all low points in the process steam distribution system.
- Steam traps should be installed wherever there is a sudden change in direction.
- All valves, especially those that will be in the off position, should have steam traps installed behind them in the distribution system.
- Drip pockets should be used in conjunction with steam traps.
- When using drip pockets, follow suggested guidelines and parameters, making sure drip pockets are properly sized and installed.

**Best Practices—Utilize Proper Insulation on all Steam Lines**

- Insulate as many steam lines, condensate return lines, and ancillary components as economically feasible.

**Best Practices—Correct Pipe Sizing**

- Follow the guidelines provided in Section 5.5.4.3 when sizing piping for a new design or retrofit.
- Steam line velocities should never exceed 10,000 feet per minute.

**Best Practices—Additional Steam Line Needs**

- Air vents and pressure gauges should be installed on all steam lines.
- Standard operating procedures for using air vents at startup should be instituted.
- Ball valves with a class four shutoff should be used in conjunction with air vents.
**Best Practices—Proper Maintenance**

- Steam and condensate piping should be checked periodically and repaired, if needed.
- Steam piping should be checked periodically for thickness using an ultrasonic thickness meter. Physical inspection during downtimes is also a good practice.
- Consider corrosion coupons for the piping of condensate systems. This will help determine chemical treatment effectiveness and gauge the condition of the piping.

**Best Practices—Remove Air from the Steam System**

- All heat transfer units require air-venting mechanisms.
- All heat transfer units require vacuum breakers. (Check valves that have been installed backwards do not suffice as vacuum breakers.)

**CHILLERS BEST PRACTICES**

**Best Practice—System Logs**

- Maintain an accurate log of the primary indications of system operations. This should include condenser and evaporator entering and leaving temperatures, chiller load, various pressures (oil, refrigerant, etc) depending on chiller type, equipment in operation, motor voltage and amperage, weather conditions, and any other important factors.

**Best Practice—Use of Demand Limiters and Staggered Start**

- The use of demand limiting can yield significant savings in energy costs in the category of demand charges. Most centrifugal chillers have either manual or automatic demand limiters. The use of these limiters can reduce the demand in any one period. When starting multiple chillers, stagger the starts at least by one demand period. Start the second chiller after the first has loaded.

**Best Practice—Chill Water Reset**

- Reset the chill water temperature to the maximum required to meet the load on the system. This is best accomplished with automated controls and programming to reset on a dynamic basis.

**Best Practice—Monitor for Refrigerant and Air Leaks**

- Periodically check low-pressure systems for excess air and high-pressure systems for proper refrigerant levels. Maintain a log of the results
Best Practice—Refrigerant Level Monitoring

- For centrifugal chillers, monitor and log the sight glass levels in the evaporator shell. Check for bubbles in the liquid line sight glass on reciprocating units, which indicate low level and high discharge pressure or low refrigerant temperature leaving the condenser for high levels. Maintain the level according to the manufacturer’s instructions.

Best Practice—Condenser (cooling tower) Temperature

- Maintain the lowest condenser temperature recommended by the chiller manufacturer. Tower fans may consume some of the increased energy, but savings from the much larger compressor will offset it.

Best Practice—Maintain Cooling Tower Discharge Temperature

- Ensure that neither mechanical nor insulation issues are responsible for any temperature increases between the cooling tower and the chiller.

Best Practice—Maintain Chiller Condenser Tubes in a Clean Condition

- The first line of defense is to follow good water treatment practices. This includes taking steps to control biocides, algae, and suspended solids. Filtration will assist in suspended solids control. Brush or high-pressure water cleaning of condenser tubes should be done annually at a minimum.

Best Practice—Condenser Water Flow

- Verify the condenser water flow by measuring it at least annually. A clamp-on or insertion flow meter can achieve this, if permanent measurement tools are not installed.

Best Practice—Motor Cooling

- When reviewing chiller logs, pay particular attention to the motor amperage vs. voltage to detect increases in amp draw. Check the motor for cooling problems. This should be a part of all annual chiller reviews.

Best Practice—Chiller Employment

- Always consider efficiency vs. load when starting and stopping chillers. Various chiller designs have different partial load and full load efficiencies. Also, consider the efficiency of the chillers on line as a group. Choose the best combination for the best energy efficiency.
*Best Practice—Chiller Water Flow Isolation*

- Isolate both the chiller evaporator and condenser from the system when the chiller is not in service. Automatic valves are the ideal solution.

*Best Practice—Variable Speed Drive Chillers*

- The availability of variable speed chillers has improved in recent years, thus reducing initial purchase costs. The use of drives allows the chiller to exactly match the compressor speed to the load and provides the ultimate in employment matching. When using multiple chillers, employment can be controlled to use the VSD-equipped chiller as the swing chiller and maximize the benefit if only one chiller is equipped with a VSD.

*Best Practice—Chiller Plant Automation, Reporting, and Control*

- The use of a well-designed automation package can greatly reduce the energy consumption of a chiller plant and provide an improved level of monitoring and reliability.

*Best Practice—Automatic Tube Cleaning Systems*

- On evaporators and condensers in high fouling applications, automatic tube cleaning systems can save significant energy by maintaining tube heat transfers surfaces in clean condition.

*Best Practice—Free Cooling on the Waterside*

- A careful analysis of free-cooling opportunities is required when winter cooling is needed and outside air is not available (or cannot be used for other reasons). Attention should be paid to the required chill water temperature in cold weather, as typically the chill water temperature can be higher than in the summer months. This is usually due to lower loads in the winter. The warmer the chill water temperature required, the longer free-cooling can be used. Free-cooling applications have been used successfully in the southeastern U.S. for many years. Depending on the application and installation, paybacks of less than one year have been achieved. Automation of the controls for change over is recommended, as it will greatly increase the number of hours of use.

*Best Practice—Free Cooling for Low Temperatures*

- The use of a fin-fan coil to cool brine solutions to temperatures below 36°F is a source of winter energy savings. The outside coil acts as the chiller and only requires a small amount of energy for the fan(s).
**Best Practice—Cooling Tower Water Filtration**

- The use of side-stream sand filters is the most effective way to remove the suspended solids in cooling tower water. Filters designed for this purpose can remove 90-95% of all suspend solids larger than 5 microns. This level of filtration, which is equal to or better than drinking water, will eliminate the problems associated with dirty cooling tower water. Selection and sizing is site-, equipment-, and location-dependant. Because the solids are small and airborne (making them low in specific gravity), centrifugal separators are not effective for this application.
- A filtration system should include a properly designed basin sweeper system to reduce or eliminate the sludge blanket that forms in tower basins.

**Best Practice—Hot Deck Covers**

- On cooling towers with hot decks, install and maintain hot deck covers. Ensure that procedures require the replacement of the covers following maintenance activities.

**Best Practice—Hot Deck Nozzles**

- Hot deck nozzles should be inspected on a monthly basis in normal operating conditions. Where frequent problems are encountered with nozzle plugging, install a line strainer on the return line to the tower. The perforations in the strainer should be one-half the size of the smallest opening in the hot deck nozzle. Install a 2-inch ball valve in a convenient location for blow down of the strainer, and check it frequently.

**Best Practice—Cooling Tower Basins**

- Order new cooling towers with stainless steel basin for longer life and reduced maintenance costs. Use epoxy or elastomeric coatings to extend the life of galvanized cooling tower basins. See also “Cooling tower water filtration.”

**Best Practice—Cooling Tower Type Selection**

- The most efficient tower type, for most conditions, is the induced draft, counter-flow design. Consider operating efficiency and lifecycle costs when selecting a cooling tower design.

**Best Practice—Vibration Switches**

- All cooling tower fans should be equipped with a shutdown vibration switch. In the event of an unbalanced situation, the fan will shut down before causing additional blade failure and the possibility of a safety hazard. Care should be taken to install the vibration switch in the correct plane for cooling towers. Switches installed in the wrong plane will not function. Switches should be checked on an annual basis for correct operation.
**Best Practice—Cooling Tower Upgrades**

- Consult a knowledgeable company to evaluate the improvements available to enhance the capacity of an existing cooling tower.

**Best Practice—Drift Control**

- Maintain drift eliminators in good condition. If drift is a problem, consider replacing the drift eliminators. Drift eliminators affect the tower performance by increasing the pressure drop and, therefore, the airflow across the tower. There is a trade-off between energy, performance, and drift control. Use the type of drift eliminator that meets the requirements, not necessarily the best one available.

**Best Practice—Winter Tower Freeze Control**

- The use of a drain-back tank is a cost-effective way to avoid tower freezing and the cost of heaters, controls, and heater operation. Space must be available in a heated area at an elevation lower than the base of the tower.

**Best Practice—Cooling Tower Cleaning**

- The cleaning of cooling towers should be done often enough to prevent any significant buildup of dirt in the tower and tower fill.

**Best Practice—Heat Exchangers**

- The various types of heat exchangers should be considered before purchasing a unit. For most HVAC applications, plate-and-frame units or tube-and-shell units are the most common. A variation on the plate-and-frame heat exchanger, the brazed plate heat exchanger, is an excellent unit for small heating, cooling, and condensing applications.

**Best Practice—On-line Heat Exchanger Cleaning**

- When using dirty or fouling-type liquids in heat exchangers, consider using back flushing for on-line cleaning. In certain tube-and-shell units, captured brushes can be used.

**Best Practice—Glycol Additions for Antifreeze**

- Use the least amount of glycol possible to prevent freezing, to maximize heat transfer and minimize the flow required for the application.
PUMP AND MOTOR BEST PRACTICES

Best Practice—Consider and Apply the Best Control System and Pump

- Consider the divergence of system curves based on the frictional and static head distributions of the pumping system in order to select/modify pumps and their control systems.
- Adjust the control system to fit the most appropriate system curve.

Best Practice—Monitor System Variability

- Monitor the flow rate over time to help clarify time distribution requirements.
- Select a flow system that is in concordance with observations of the flow rate.

Best Practice—Select an ON/OFF Control System for Systems with no Flow Rate or Head Regulations

- If a study of the variability and regulations of the system (Sections 7.1.1, 7.1.2) shows that flow rate and head do not need regulating, investigate an ON/OFF system, which will likely provide the lowest capital and operating costs.

Best Practices—Adjustable Speed Drive or Multiple Parallel Pump Controls

- Installing a variable speed drive on the motor will adjust the pump operation to meet a variable demand system.
- In cases with high static head, parallel pumps may be a more effective alternative.

Best Practice—Parallel Pump Control

- If there are multiple obvious flow regimes noticed from the system, investigate the option of parallel pumps to handle the different regimes.

Best Practice—Minimize the Use of Throttling and Bypass Controls

- Use only the optimum number of throttling and bypass valves to reduce frictional losses in the system.
- Be aware that installing a control valve or bypass valve may be a better alternative to other control methods, such as using adjustable speed drives.

Best Practices—Demand Charge Minimization

- Coordinate equipment operation times to level out demand peaks.
- Install capacitors on motors to improve the power factor.
- Use synchronous motors to increase the power factor.
**Best Practice—Prevent Excessive Conservatism in Design**

- Base purchase and design decisions on lowest lifecycle costs.
- Match true system requirements.
- Select the pump that is closest to the BEP (Best Efficiency Point on pump diagram).
- Select equipment with future changes in mind
- Ensure that installation follows standard recommended practices (particularly for suction)

**Best Practice—Conduct a Lifecycle Cost Analysis**

- Conduct a lifecycle cost analysis to improve the accuracy of design and equipment selections. (Section 7.1.2)

**Best Practice—Test the System After It Is Installed**

- After installation, startup testing, early operational phases, and stable operation have been achieved, review actual system performance to determine the cost of the differences between actual operation and an operating environment.
- Resize equipment to eliminate losses.
- Select the pump to operate close to the Best Efficiency Point (BEP).

**Best Practice—Consider the Future when Selecting New Equipment**

- Install a pump model that efficiently meets current needs but can be easily and cost effectively upgraded (or downgraded) in the future by adding stages or changing impellers.
- Install a pump with an adjustable speed drive, and adjust pump speed to meet both current and future needs.
- Provide sufficient space for equipment replacement or augmentation, as needs change.

**Best Practice—Avoid Pump Geometries that Cause Unbalanced Flow Distribution**

- Ensure that the flow maintains a balanced distribution entering the pump inlet to prevent cavitations.

**Best Practice—Optimize Pipe Sizes**

- Compute annual and lifecycle costs for the system before making an engineering decision.
- In systems dominated by frictional head, consider multiple options when trying to accommodate pipe size with lowest overall lifecycle cost.
- Search for ways to reduce the friction factor of the system. Certain piping materials, (if applicable), may reduce the friction factor by as much as 40%, proportionally reducing pumping costs.
Best Practice—Use Prescreening Processes to Identify Systems with Energy Savings Potential

- Use PSAT-based analysis to identify potential energy saving opportunities.

Best Practices—Implement a Motor/Pump Maintenance Program

- Develop and use a maintenance program

PRINTED MATERIAL


   The full document can be purchased from the Hydraulic Institute at www.pumps.org; an executive summary (and other useful documents) can be requested free of charge from Hydraulic Institute at http://www.pumps.org/public/pump_resources/energy/index.html.


ON-LINE RESOURCES
Software Tools

A good source for software tools is the DOE website, [www.doe.gov](http://www.doe.gov). This website branches off into sub-sites, many which provide the items listed above. The following software tools are available from the DOE Industrial Technologies Program:


- AIRMaster+, a compressed air assessment package
- Fan System Assessment Tool, a fan optimization package for various fan system configurations
- MotorMaster+ 4.0, an energy efficient motor selection guide and management tool
- NOx and Energy Assessment Tool, a software package that helps assess NOx emissions and applications of energy efficiency improvements
- Process Heating and Assessment Survey Tool, a program which provides introductions to process heating methods as well as tools to help improve the thermal efficiency of heating equipment
- Pumping System Assessment Tool 2004, helps industrial users assess the efficiency of pumping system operations
- Steam System Tool Suite, collection of tools which help identify steam system improvements

DOE-EERE, [http://www.eere.energy.gov/industry/chemicals/chemicals_ind_tools_cd.html](http://www.eere.energy.gov/industry/chemicals/chemicals_ind_tools_cd.html)

- Chemical Industry Tools CD, provides resources and tools such as new innovative energy efficient technologies, energy analysis software tools, hands-on tips, plant assessment information, financial assistance and more

DOE-EERE, [https://sslserver.com/bcstools.net/CPAT/login.asp](https://sslserver.com/bcstools.net/CPAT/login.asp)

- CPAT 2.2, user inputs provide a measure of the potential commercial deployment of new processes, technologies, and practices

Case Studies and R&D Projects

Case studies offer information about energy audits conducted on manufacturing facilities. This information includes descriptions of the processes modified, successes, and experiences from the audits. Along with information from previous studies, the DOE Energy Efficiency and Renewable Energy Program offers information on active studies. The DOE is currently looking for companies to participate in these studies. The following websites provide information pertaining to case studies as well as current and past research and development projects:

- These case studies describe the energy improvement projects, process improvement projects, and assessments at the plant level.


- This website provides contact information on emerging technologies in the chemical industry.

DOE-EERE, [http://www.eere.energy.gov/industry/chemicals/portfolio.html](http://www.eere.energy.gov/industry/chemicals/portfolio.html)

- This website provides information on past and current research and development projects, DOE partnerships in Industry, and current events being held by the DOE.


- Search through a case study database to find case studies applied to different facility types.

COMPRESSED AIR CHALLENGE, [http://www.compressedairchallenge.org/](http://www.compressedairchallenge.org/)

- This website contains a case study index dedicated to the improvement of compressed air systems.

ORGANIZATIONS


Boiler Efficiency Institute, [www.boilerinstitute.com](http://www.boilerinstitute.com)

Center for Analysis and Dissemination of Demonstrated Energy Technologies (CADDET) [www.cadet.org](http://www.cadet.org)

Center for Industrial Research and Service [http://www.ciras.iastate.edu](http://www.ciras.iastate.edu)

Compressed Air Challenge, [http://www.compressedairchallenge.org](http://www.compressedairchallenge.org)


Energy Services, http://www.energyexperts.org/


Environmental Energy Technologies Division, Energy Analysis Department, http://eetd.lbl.gov/EA.html


Iowa Energy Center, www.energy.iastate.edu

Industrial Assessment Center, Industrial Assessment Center at Iowa State University at (515) 294-3080 http://iac.rutgers.edu/database/main.php.

Iowa State University Industrial Assessment Center (IAC), (515) 294-3080 www.me.iastate.edu/iac

MidAmerican Energy http://www.midamericanenergy.com


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