

# Energy Tips



Steam



Motors



Compressed Air

## Use Vapor Recompression to Recover Low-Pressure Waste Steam

Low-pressure steam exhaust from industrial operations such as evaporators or cookers is usually vented to the atmosphere or condensed in a cooling tower. Simultaneously, other plant operations may require intermediate-pressure steam at 20 to 50 pounds per square inch gauge (psig). Instead of letting down high-pressure steam across a throttling valve to meet these needs, low-pressure waste steam can be mechanically compressed or boosted to a higher pressure so that it can be reused.

Vapor recompression relies upon a mechanical compressor or steam jet ejector to increase the temperature of the latent heat in steam to render it usable for process duties. Recompression typically requires only 5 to 10 percent of the energy required to raise an equivalent amount of steam in a boiler.

Energy Required for Steam Recompression					
Inlet Pressure (psig)	Compressor Work, Btu/lb of Steam Produced				
	Compression Ratio				
	1.2	1.4	1.6	1.8	2.0
0	17.8	33.2	46.8	58.8	69.6
15	18.6	34.7	48.7	61.2	72.6

Assuming adiabatic compression with a compressor efficiency of 75 percent. 80°F water is sprayed into the steam to eliminate superheat.

### Example

Consider a petrochemical plant that vents 15-psig steam to the atmosphere. At the same time, a process imposes a continuous requirement on the boiler for 5,000 lbs/hr of 40-psig steam. If 15-psig waste steam is recompressed to 40 psig by an electrically driven compressor, the compression ratio is:

$$\text{Compression Ratio} = (40 + 14.7) / (15 + 14.7) = 1.84$$

From the table above, the compressor requires 63.5 Btu/lb of delivered steam. Assuming that electricity is priced at \$0.05/kWh, the annual cost of driving the compressor is:

$$\begin{aligned} \text{Compressor Operating Cost} &= 63.5 \text{ Btu/lb} \times 5,000 \text{ lbs/hr} \times 8,760 \text{ hrs/yr} \times \$0.05/\text{kWh} / 3413 \text{ Btu/kWh} \\ &= \$40,745/\text{year} \end{aligned}$$

If an equivalent quantity of 40-psig steam (enthalpy for saturated steam is 1176 Btu/lb) were to be supplied by an 82-percent efficient natural-gas-fired boiler, the steam production costs with fuel priced at \$4.50/MMBtu and 70°F feedwater (enthalpy is 38 Btu/lb), are:

$$\begin{aligned} \text{Steam Production Costs} &= 5,000 \text{ lbs/year} \times (1176 - 38 \text{ Btu/lb}) \times 8,760 \text{ hrs/yr} \times \$4.50/\text{MMBtu} / 0.82 \\ &= \$273,536/\text{year} \end{aligned}$$

$$\text{Annual Vapor Recompression Cost Savings} = \$273,536 - \$40,745 = \$232,791$$

### Conduct a Pinch Analysis

Based on the actual application, there may be other options to vapor recompression. The industry best practice is to conduct a pinch analysis on the steam system to reveal cost-effective alternatives and optimize steam use by eliminating inefficiencies.

### Vapor Recompression Limits

Vapor recompression is limited to applications where the compressor inlet pressure is above atmospheric and the compression ratio is less than two per stage.

### System Pressure Boosting

Vapor recompression can be used in steam distribution systems to boost system pressures that have dropped to unacceptably low levels.

*Adapted from an Energy TIPS fact sheet that was originally published by the Industrial Energy Extension Service of Georgia Tech. For additional information on steam system efficiency measures, contact the OIT Clearinghouse at (800) 862-2086.*



## Suggested Actions

A vapor recompression project analysis consists of matching recovered waste heat with the need for low-pressure steam for process or space heating. To perform this analysis:

- Conduct a plant audit to identify sources of low-pressure waste steam.
- Estimate the heat recovery potential.
- Inventory all steam-utilizing equipment and list pressure requirements, energy consumption, and patterns of use.
- Estimate the cost-effectiveness of installing recompression equipment and connecting piping.



BestPractices is part of the Office of Industrial Technologies' (OIT's) Industries of the Future strategy, which helps the country's most energy-intensive industries improve their competitiveness. BestPractices brings together the best-available and emerging technologies and practices to help companies begin improving energy efficiency, environmental performance, and productivity right now.

BestPractices focuses on plant systems, where significant efficiency improvements and savings can be achieved. Industry gains easy access to near-term and long-term solutions for improving the performance of motor, steam, compressed air, and process heating systems. In addition, the Industrial Assessment Centers provide comprehensive industrial energy evaluations to small and medium-size manufacturers.

### FOR ADDITIONAL INFORMATION, PLEASE CONTACT:

Theo Johnson  
Office of Industrial Technologies  
Phone: (202) 586-6937  
Fax: (202) 586-6507  
Theodore.Johnson@hq.doe.gov  
[www.oit.doe.gov/bestpractices](http://www.oit.doe.gov/bestpractices)

OIT Clearinghouse  
Phone: (800) 862-2086  
Fax: (360) 586-8303  
[clearinghouse@ee.doe.gov](mailto:clearinghouse@ee.doe.gov)

Please send any comments,  
questions, or suggestions to  
[webmaster.oit@ee.doe.gov](mailto:webmaster.oit@ee.doe.gov)

Visit our home page at  
[www.oit.doe.gov](http://www.oit.doe.gov)

Office of Industrial Technologies  
Energy Efficiency  
and Renewable Energy  
U.S. Department of Energy  
Washington, DC 20585-0121



DOE/GO-102001-1274  
May 2001  
Steam Tip Sheet #11

## About DOE's Office of Industrial Technologies

The Office of Industrial Technologies (OIT), through partnerships with industry, government, and non-governmental organizations, develops and delivers advanced energy efficiency, renewable energy, and pollution prevention technologies for industrial applications. OIT is part of the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

OIT encourages industry-wide efforts to boost resource productivity through a strategy called Industries of the Future (IOF). IOF focuses on the following nine energy- and resource-intensive industries:

- Agriculture
- Aluminum
- Chemicals
- Forest Products
- Glass
- Metal Casting
- Mining
- Petroleum
- Steel

OIT and its BestPractices program offer a wide variety of resources to industrial partners that cover motor, steam, compressed air, and process heating systems. For example, BestPractices software can help you decide whether to replace or rewind motors (MotorMaster+), assess the efficiency of pumping systems (PSAT), or determine optimal insulation thickness for pipes and pressure vessels (3E Plus). Training is available to help you or your staff learn how to use these software programs and learn more about industrial systems. Workshops are held around the country on topics such as "Capturing the Value of Steam Efficiency," "Fundamentals and Advanced Management of Compressed Air Systems," and "Motor System Management." Available technical publications range from case studies and tip sheets to sourcebooks and market assessments. The *Energy Matters* newsletter, for example, provides timely articles and information on comprehensive energy systems for industry. You can access these resources and more by visiting the BestPractices Web site at [www.oit.doe.gov/bestpractices](http://www.oit.doe.gov/bestpractices) or by contacting the OIT Clearinghouse at 800-862-2086 or via email at [clearinghouse@ee.doe.gov](mailto:clearinghouse@ee.doe.gov).