Mechanical Insulation Design Guide - Case Studies

by the National Mechanical Insulation Committee (NMIC)

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Department of Energy (DOE) - Industrial Technologies “Save Energy Now” (SEN) Program
Energy is often one of the most costly components of operating any manufacturing facility and its processes. A reduction in energy consumption reduces cost. Without exception, this is a continual objective of most companies. It may not be at the top of the list, but certainly within the top ten of corporate initiatives. While insulation can be one of the easiest, fastest and least costly “technologies” to reduce energy cost, it is often the last option considered.

It is interesting to review the process for determining the design criteria for insulation on new construction or expansion projects verses the maintenance process and how priorities are established. In new construction, the primary driver in determining the insulation system is the process. Very seldom is the insulation system or thicknesses examined from an energy conservation perspective. Once a facility or plant is operating and the energy consumed is a reality, as opposed to a theory, it seems that compliancy or acceptance of the results outweighs examining actual results in comparison to original expectations. Properly and timely maintaining an insulation system seems to mostly reactionary verses proactive.

It has been estimated that between 10—30% of all installed mechanical insulation is either damaged or missing. The question that must be asked is why does this condition exist when it can be corrected and provide a significant return on the capital employed or maintenance dollars expended?

The Department of Energy (DOE) - Industrial Technologies, “Save Energy Now” (SEN) Program is part of a national campaign by the DOE to help manufacturing facilities reduce energy and operating costs and operate more efficiently and profitably. Independent specialists who have been trained in the utilization of sophisticated software assessment tools and have passed a rigorous qualifying exam, visit a plant and work with personnel to identify immediate and long-term opportunities for improving energy efficiency and bottom-line results. Mechanical insulation is one of the many opportunities that are examined.

Of the SEN assessment studies published to date (September 07), 53% have identified replacing, repairing and upgrading the mechanical insulation as an opportunity of which 84% have estimated a return on investment in less than a year.

Following are but a few example excerpts from the SEN survey results which are classified as “near term” opportunities—payback in less than one year: (Assessment results determined by review and interpretation of available data. (Please refer to the Save Energy Now web site, www.eere.energy.gov/industry/saveenergynow, for specific and detailed information on these and other examples. The information shown does not depict all aspects of the reported assessment results for the respective facility)

Bayer (2 Steam Plants), Institute, WV
By improving and replacing missing insulation on the steam and condensate lines - Potential savings $926,000 per year

Boise Cascade (Paper Mill), Jackson, AL
By replacing missing pipe insulation - Estimated savings $80,000 per year, cost to complete the work $25,000 = 3.8 month payback

Dow Chemical (Chemical Plant), Hahnville, LA
By replacing, repairing and improving insulation on steam system - Potential annual savings of $811,000

General Motors (Power Plant), Pontiac, MI
By replacing missing insulation and repairing other areas - Estimated annual savings of $298,000

Goodyear, Union City, TN
A significant number of process units are partially insulated. Potential savings, $402,000 per year. Estimated payback 2.5 to 6 months depending upon cost of completing the work. “This same opportunity can be applied to other company facilities.”

National Starch (Power Plant), Indianapolis, IN
By replacing and repairing insulation - Estimated annual savings of $125,000

Sterling Chemical (Chemical Plant), Texas City, TX
Improvements in the insulation - Potential annual savings of $123,000

Mead Westvaco, Silsbee, TX
Commissioned an “Insulation Strike Team” to go through the plant to repair areas of poor, damaged or missing insulation. They determined that reducing insulation heat loss by 10% would yield savings of over $486,000 per year

United States Steel, Gary, IN
Estimated that by using proper type, size and thickness of insulation and improving maintenance of the insulation systems could result in annual savings in excess of $1,500,000 per year

Mittal Steel, Weirton, WV
By insulating hot water washing tanks, 140 F operating temperature, located throughout the facility, 50,000 SF of surface area, with an inexpensive - simple insulation system the annual savings would be $371,000 + per year

Eastman Chemical, Kingport, TN
“The thermal insulation system throughout the site is observed to be in good condition...several pipes observed to be missing insulation. The approach taken in investigating and illuminating insulation issues is excellent and considered to be a Best Practice approach”

One heat tracing system is not completely evaluated yet - identified savings $1,000,000 with re-insulation cost of $300,000 = 4 month ROI

Steam system will be evaluated - preliminary investigation indicate a potential savings of additional $1,000,000 with return ranging from 1 to 3 years

“Improving From the Outside In” Insulation upgrades to the outside pipelines at NOCO Energy Corporation improve energy efficiency-and the company’s bottom line.”

NOCO Energy Corporation has a large terminal operation outside of Buffalo, New York, in Tonawanda. From that terminal, NOCO distributes petroleum and petroleum products to the western New York area. Among the petroleum-based products that NOCO distributes are asphalt and No. 6 fuel oil, which must be kept in heated storage tanks and distribution pipelines. Without heated tanks, piping, and equipment, these products cannot be pumped.

Multiple Challenges To Meet
Over the years, it became increasingly difficult for NOCO to maintain adequate temperatures in storage tanks and pipelines. This resulted in slow pumping and transfer rates through the pipelines, as well as periodic plugging. These problems made it difficult to run the terminal efficiently and cost-effectively.

NOCO’s location along the shore of Lake Erie in western New York did not help. Winter temperatures can reach -20°F, annual snowfall surpasses 90 inches, and winds average 12 miles per hour (mph), with peak winds well over 50 mph. These severe factors made maintaining sufficiently high operating temperatures more difficult—and even more critical.

The situation was aggravated further by the terminal layout. It is spread out, requiring long pipelines from the lakefront barge-loading facilities and the storage tanks. Additionally, the terminal used a heated-oil heat transfer fluid to maintain the temperatures in the storage tanks and pipelines, with the heaters located at the northern end of the terminal. This also made for long heated-oil transfer lines.

The final problem was the terminal's damaged insulation systems, especially on the product pipelines and heated-oil supply lines. All of these lines are located in ground-level horizontal pipe racks. Over the years, between people stepping on the pipelines, maintenance activity, and the effect of the Buffalo-area weather, the insulation systems degraded. The systems' poor condition contributed significantly to the terminal's difficulty maintaining temperature in the asphalt and No. 6 fuel oil tanks and pipelines.

First Solutions First
Revision of the heated-oil transfer system was the first priority. Management submitted a project to design and install another heated-oil heater, located toward the southern section of the terminal. Revising the system would improve heat transfer and pumping efficiency.

The terminal staff believed upgrading the insulation systems would improve the overall reliability and efficiency of the systems, as well as save on energy costs. With the help of the New York State Energy Development and Research Authority (NYSERDA)—see "NYSERDA Offers Energy-Saving Expertise"—and the engineering firm Clough, Harbour, & Associates, they performed an evaluation of all of the insulation systems and determined the economic impact of upgrading all affected insulation systems, including the addition of 2 inches of insulation to the existing 2 inches. Because the terminal had a readily available, low-cost fuel source for the heated-oil heaters in used motor oil, the initial evaluation indicated an unusually long payback period for an insulation upgrade project like this—around 3 years.

An Unexpected (and Lucrative) Turn of Events
About the time the original assessment was performed, terminal staff found that the used motor oil being used for fuel in the heated-oil heaters was in greater demand. So any fuel saved from burning in the heated-oil heaters could be sold profitably. This increased interest in the insulation upgrade.

The new heated-oil heater was installed, but only some of the insulation was upgraded for several reasons, including schedule, equipment availability, and budget. Part of the problem was the fact that the insulation systems were much more damaged than originally assumed and had to be completely replaced.

Because the addition of the new heated-oil heater and some rerouting of heated-oil lines were projected to actually increase fuel consumption and cost to the terminal, it became more complex to analyze the benefit of the insulation upgrade project to the overall facility.

Through the efforts and resources of NYSERDA, a review of the work and an analysis of the energy savings on the upgraded insulation systems were performed using both proprietary and 3E Plus® software (see "The Power of 3E Plus"). The following are the results of the analysis:

- Projected energy savings of **approximately 10 billion Btus per year or more than $87,000**
- Projected used motor-oil savings (that can be sold in the marketplace at approximately $1 per gallon) of **around 87,000 gallons**
- Projected payback: slightly more than 1 year
- Carbon dioxide (CO_2) reduction: **more than 2.3 million pounds of this greenhouse gas per year**
- More than **4,500 pounds** of nitrogen-oxygen compounds (NO_x) class of regulated emissions, which includes both greenhouse gases and other gases that influence the mixing ratio of greenhouse gases

“Though it is difficult to quantify the fuel savings that resulted from this project, the original heating system was grossly undersized for our needs,” says Val Speek, terminals and facilities manager at NOCO Energy Corporation. “Burners were running at a 100-percent firing rate and were unable to meet the Btu demand for heating our asphalt. The addition of a new thermal fluid heater and the replacement of damaged insulation resulted in a surge of customer satisfaction. The heater played a major role in maintaining our marketing tanks at an acceptable temperature, while the replacement of damaged line insulation increased efficiency and eliminated customer complaints of cold asphalt”.

“This is the first year I can remember having no problems loading asphalt in the cooler weather,” Speek adds.

Paul D. Tonko, NYSERDA’s president and chief executive officer (CEO), says, “Through NYSERDA’s Flex-Tech program, we’ve assisted NOCO in operating its distribution terminal more efficiently while maintaining profitability. Our study of the facility identified significant areas of energy-efficient infrastructure and productivity improvements to the rail facility, heat transfer system, tank farm, and pump motors. As a result, NOCO’s $5-million capital investment has led to $500,000 per year in energy and productivity benefits, 16 indirect jobs, and the equivalent of 20,000 barrels of oil saved annually. NYSERDA is proud to have partnered with NOCO Energy Corporation and Clough, Harbour, & Associates in making the necessary energy efficiency upgrades at the facility.”

Even better than the projected cost savings and emission reductions from energy efficiency is the fact that the properly insulated lines now pump product easier and faster, with far fewer plugging problems, allowing the terminal to operate more efficiently and profitably. The facility’s overall result is a win-win situation—a better-running terminal, more recycled motor oil to sell rather than burn in the heated-oil heaters, and less environmental impact due to fewer greenhouse gas emissions.

The Power of 3E Plus®

The 3E Plus® software program from the North American Insulation Manufacturers Association (NAIMA) is an invaluable industrial energy management tool that can be used to calculate energy savings and determine the most energy-efficient use of insulation. It also helps users—including facility managers, energy and environmental managers, industrial process engineers, and industrial plant managers—reduce plant emissions, improve system process efficiency, and determine return on investment (ROI) of insulation upgrades.

3E Plus is designed to allow users to calculate heat losses and determine surface temperatures on hot and cold piping, as well as equipment. The program can:

•calculate the thermal performance of both insulated and uninsulated piping, ducts, and equipment;
•translate British thermal unit (Btu) losses into actual dollars; and
•calculate greenhouse gas emissions and reductions.

The latest version of 3E Plus can be downloaded for free at Pipeinsulation.org. The program includes thermal conductivity curves from ASTM Material Specifications for most insulation types. Users have the option of inputting thermal data from other sources, if desired.

Learn how to use 3E Plus effectively by taking the National Insulation Association’s (NIA’s) Insulation Energy Appraisal Program (IEAP), which is a fully accredited certification program. For more information, please visit www.insulation.org/training/ieap.

NYSERDA Offers Energy-Saving Expertise

The New York State Energy Research and Development Authority (NYSERDA) was established by a 1975 law as a public benefit corporation. It is devoted to using innovation and technology to solve some of New York’s most challenging energy and environmental problems in ways that improve the state’s economy. NYSERDA offers sophisticated energy-efficient construction advice, services, and funding for new construction and rehabilitation improvements. Its efforts are concentrated largely on improving the environment, especially in relation to the emissions associated with the generation and consumption of energy.

Since 1990, NYSERDA has successfully developed and brought into use more than 170 innovative, energy-efficient, and environmentally beneficial products, processes, and services. It works with hundreds of businesses, schools, and municipalities to identify existing technologies (such as insulation) and equipment to reduce energy costs.

For more information on NYSERDA and its energy-saving efforts, please call 866-697-3732 or visit www.nyserda.org.

Case Study conducted by Michael Lettich. Mike Lettich is the principal consultant of MJL Consulting, where he helps the chemical, petroleum, pharmaceutical, pulp and paper, utility, and other industries improve their maintenance programs. He consults in insulation, coatings, and contractor effectiveness. A chemical engineer, he previously worked for DuPont, from which he retired after 28 years. While at DuPont, he helped implement the Thermal Insulation Maintenance Service® (TIMS®), providing strategic, focused, cost-effective insulation maintenance programs in industry.

Georgia-Pacific Reaps Benefits by Insulating its Steam Lines
Insulation upgrade program reduces fuel costs and increases process efficiency at Georgia-Pacific plant

Built in 1979, the Georgia-Pacific plant at Madison, Ga., uses Loblolly pine to manufacture plywood. The tree is abundant in the area. Most of the trees harvested are within a 180- mile radius of the mill. About 20 percent of the trees are grown on land owned by Georgia-Pacific and about 80 percent come from other privately owned land. The plant runs 24 hours, 7 days a week and employs approximately 400 people.

The process of making the veneer layers in a plywood panel begins when logs arrive at the mill in sections. They are immediately debarked and soaked in water at 180°F for six hours. This softens the logs and enables them to peel better. The softening process also allows the logs to pass through the lathe much easier and delivers the veneer layers at the right temperature to the dryer where they are dried at temperatures of 405°F.

From the dryers, the veneer layers go to the glue line where layers are sandwiched with glue and then pressed into a panel. From there the panels go to the saw line for trimming before banding and shipping.

Because the steam lines to the dryer were uninsulated, heat was radiating out and millions of Btu were being lost. The heat loss resulted in a loss of pressure and a reduction in temperature as the plywood moved down the line. The increased drying time needed slowed the process down significantly.

While Georgia-Pacific wanted to insulate the steam lines for energy conservation, improved process efficiency and personnel protection, the company also wanted the insulation for a more pragmatic reason—to eliminate dependence on purchased fuel. The plant normally uses wood bark and wood byproducts for fuel. However, at certain times of the year the bark is too thin for use as adequate fuel so additional fuel had to be purchased from an outside source.

Determining the Thickness of Insulation
Once the decision was made to insulate the steam lines, a computer program called 3E Plus created by the North American Insulation Manufacturers Association (NAIMA) was used to determine the insulation thickness required to insulate the 1,500 feet of saturated steam lines with temperatures operating at 437°F.

Computer projections estimated that insulation would significantly reduce the heat (Btu) loss along the steam lines leading to the dryers. This reduction in heat loss alone could increase the operating temperature by 15° and maintain the process temperature along the length of the lines. The combination of a higher temperature in the dryer lines and a more consistent process line temperature would result in a faster and more efficient veneer plywood process.

The Madison plant installed two-inch thick fiber glass pipe insulation. Two inches is the thickness needed to reduce heat loss, maintain process temperature and bring the outside surface temperatures of the pipes down for personnel protection. Insulation footage was as follows: 120 feet of insulation on the twelve-inch process line; 200 feet on the eight-inch process line; 220 feet on the six-inch process line; 80 feet on the four-inch process line; and 350 feet on the 1-1/2-inch process line.

A major advantage of using mineral fiber insulation to insulate the steam lines was that no downtime was required. Several areas that could not be insulated while the line was running were insulated on schedule down days. Says Jackson, “We do dryer maintenance once a week so the dryer is shut down during that time. That’s when the insulation was installed on those areas that couldn’t be accessed while the dryer was running.”

Immediate Results
The personnel at the Georgia-Pacific plant were pleased with the results of the insulation project.

Improved Process Efficiency
The lines to the mill’s four dryers have all been insulated, and according to Darryl Jackson, boiler superintendent at the Madison plant, “Gauging the increase in throughput has proven to be a bit more complex than we first thought. A more accurate gauge of the effectiveness of the insulation is the steam usage. The insulation has allowed us to cut our steam usage by approximately 6,000 lbs./hour. This is equivalent to saving about 18 tons of fuel per day. I can track these numbers with a totalizer so I know exactly what the dryers are pulling at any given time.”

Dependence on Outside Fuel Eliminated
By insulating the piping, Georgia-Pacific has been able to eliminate the purchase of fuel. Says Jackson, “Currently we are selling some of our excess fuel to a paper company.”

Reduction in Pollutants
By reducing fuel consumption, the Madison plant has been able to reduce the amount of ash being generated and estimates that the energy saved through insulation has reduced the amount of C02 emissions by 5 to 6 percent.

Increased Personnel Protection
Prior to installing the insulation, the piping in the Madison plant had a surface temperature of approximately 400°F. With insulation, the surface temperature has been reduced to approximately 85°F—a safer level for personnel protection.

In addition to insulating the steam lines, Georgia-Pacific also replaced 70 steam traps. According to Jackson, “We’ve probably gained 10 percent condensate return from replacing the thermal dynamic traps. By increasing the condensate by 10 percent, our savings will be approximately $86,000 per year based on an $8 per ton fuel cost”.

Georgia-Pacific estimates that the amount of energy saved by insulating the steam lines to the dryers and installing new steam traps is approximately 7,212,000 Btu per hour.

Payback on Initial Investment
Calculating how long it takes to pay back an initial insulation investment is an integral part of Georgia-Pacific’s energy management program. Based on the results realized, the payback period at Madison was approximately six months

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