State of Maryland

Energy Efficiency

Reduce Operating Costs

Reduces Harmful Air Pollutants

Technical Reference Manual

Mechanical Insulation

Cost Effective Measures to

Reduce the Carbon Footprint

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Mechanical Insulators LMCT

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1. Introduction

Mechanical insulation in commercial buildings is often hidden behind walls, above ceilings, and in mechanical rooms where only a few have access. In manufacturing or industrial facilities, it is more often exposed to the view of all who venture by. Yet, it seems invisible when energy conservation initiatives are investigated, and it is seldom considered from a return-on-investment perspective. An investment opportunity that can provide over a 100 percent annual return, help reduce our dependency on foreign energy sources, improve our environment, and stimulate our economy by creating thousands of "shovel ready" jobs is hidden in plain sight.

Industry has been estimating for years that between 10 percent and 30 percent of all exposed mechanical insulation becomes damaged or missing within 1 to 3 years of installation. Over time and depending on the operating environment and exposure to the elements, that percentage is likely higher. Those estimates have been confirmed by recent data in the industrial sector, and there is no reason to think the commercial sector fares better.

A modest increase in the use of energy-efficient mechanical insulation would allow the United States to quickly generate significant energy demand reductions in the industrial sector, create tens of thousands of green jobs, and help cut the nation's greenhouse gas emissions.[1]

This is a valuable intellectual concept to understand that missing (and damaged) mechanical insulation offers tremendous monetary and energy loss, not to mention the additional harmful greenhouse gases it has on the environment with releasing unnecessary carbon.

No longer can the value of mechanical insulation be considered a concept or a theory, it can be proven and measured just like any other science or technology. It will reveal the data to offer a measured calculation of its effectiveness. A Certified Mechanical Insulation Energy Appraiser can evaluate the thermal performance of facility piping and equipment and demonstrate the amount that could be saved by installing, upgrading, or maintaining mechanical insulation on mechanical systems. The appraiser performs a facility walk-through to identify existing insulated and un-insulated process systems and determines areas where mechanical insulation can be installed or upgraded. Using U.S. Department of Energy-approved 3E Plus® software and data collected during the facility walk-through, the appraiser can determine the dollar value of Btu losses and even calculate the current system's greenhouse gas emissions saved. [2]

This leads into the attractive bottom-line component of this technology and industry. When considering the amount of capital, funding, to properly insulate a mechanical system, the energy savings can a return on investment a little as 2 years, however it may be longer depending on the total scope of the work. This written analysis offers proof from small projects all the way to large building complexes and industrial/manufacturing plants. The science and the math can be calculated to surprisingly jaw dropping results.

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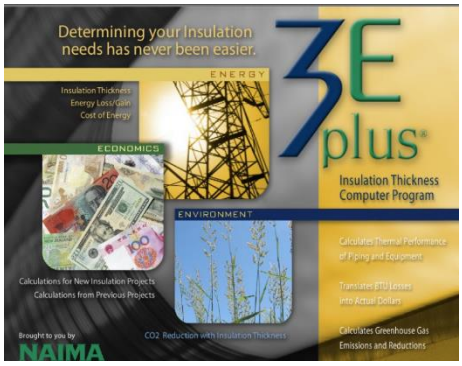
[1] Article by Ron King, NIA Insulation Outlook Magazine, www.insulation.org, Mechanical Insulation Maintenance: Proven Investment Opportunity Hidden in Plain Site.

[2] Article October 1, 2010, from Insulation Outlook Magazine, www.insulation.org Find Out Where the Dollars are Hiding in Your Facility

2. Measured Calculation Methodology– Mechanical Insulation Energy Audit

The **Mechanical Insulation Energy Audit** evaluates by use of a computer program that was developed by the **North American Insulation Manufacturer's Association (NAIMA)** and the **US Department of Energy**. With the input of collected data, it offers tangible results that is understood and allows proper fiscal and environmental decisions to be made. The name of the program is called **3E Plus**. Hence the 3 "E" represents:



- **E**nergy
- **E**conomics
- **E**nvironment

The **3E Plus** program provide calculations for several common fuel and endless insulation application scenarios. Thermal conductivity curves are built into the program for approximately 50+ insulation materials using ASTM standard material specification requirements. The program also allows user supply thermal conductivity jacketing, fuel type and base material data. This gives the program tremendous flexibility.

The **3E Plus** program calculates:

- **Heat Gain or Heat Loss (btu/h or Watts)**
- **Heat loss reduction vs bare pipe**
- **Fuel savings ($/yr.)**
- **Emission reductions (lbs./yr.)**
- **Surface Temperature (O^f or C^o)**
- **Insulation Thickness**
  - **Economic**
  - **Thermal Considerations**
  - **Condensation control**
  - **Personal protection**
- **Simple back period**

The 3E Plus program requires the following data and collection of conditions to properly conduct a Mechanical Insulation Energy Audit (MIEA). A walk-through mechanical insulation inspection is performed to obtain the data necessary such as but not limited to;

- Identification of substrate
- Size and material of substrate
- System Application – Pipe, Tank Duct – Horizontal or Vertical
- Dimensional Standard = ASTM insulation material
- Calculation Type = Cost, Energy, Pollutant Reduction
- Process Temperature
- Ambient Temperature
- Wind Speed
- Type of Fuel
- Fuel Unit Cost
- Heat Content
- Efficiency
- Hours Per Year
- Nominal Pipe Size
- Bare Metal
- Bare Surface Emittance
- Insulation Layer (ASTM insulation)

- Outer Jacket Material

All of these factors must be skillfully obtained and evaluated for the MIEA. Only certified and properly trained persons are qualified to offer MIEA at a credible value. These results are all calculated to represent the loss of energy, cost of energy and air pollutants as per foot calculation.

For Example: If a bare pipe (no insulation) is compared to an insulated pipe with at least the ANSI ASHRAE standard 90.1 of one foot. All calculation from 3E Plus uses 1' per calculation. Calculation also considers the amount of time the unit is operating in a year.

578' of exposed bare pipe of the exact description in the calculation. (a)

$115.78 cost of 1' not insulated per 3E Plus (b)

1950' total length of pipe in calculation (c)

(a) x (b) = total cost of energy wasted per year (578') x (115.78) = **$66, 920.84 for a year**

(b) / (c) = % of energy wasted per system (578') / (1950') = **29.6 % insulation missing**

7597 (lbs./ft/yr.) is CO_2 of exposed bare pipe of the exact description in the calculation (d)

444.4 (lbs./ft/yr.) of insulated pipe of the exact description in the calculation (e)

(d) – (e) (lbs./ft/yr.) amount of carbon per foot (f) (7597) – (444.4) = **7152.6 (lbs./ft/yr.)** (g)

(a) x (g) = total amount of carbon release per year (578') x (7153) = **4,134,434 CO_2 (lbs./ft/yr.)**

48,900 (KBTUs/ft/yr.) Energy consumed on bare pipe by foot per year. (h)

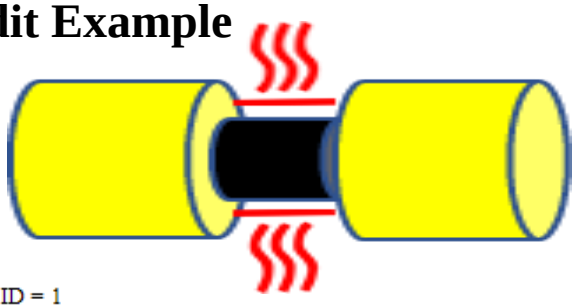
2860 (KBTUs/ft/yr.) Energy consumed on insulated pipe by foot per year. (i)

(h) x (i) = total cost of energy wasted per ft/yr. (48,900) – (2860) = **46, 0404 KBTUs/ft/yr. (j)**

(a) x (j) = total energy release per year (578') x (46, 0404) = **26,611,120 KBTUs/ft/yr.**

This is just an example of the methodology used in the calculations of a Mechanical Insulation Energy Audit (MIEA). Usually, once an initial MIEA is performed and presented, it raises the awareness and education to various entities that future sound business decisions can be made without the logistics of additional MIEAs. Once an individual or even committee understand the value of mechanical insulation MEIA usually becomes tedious.

3. Mechanical Insulation Energy Audit Example



Horizontal low pressure 6” steam pipe, steel.
Operating temperature is 380° F
Using 2” fiberglass ASTM Pipe Insulation
Operates ¾ of a year - 6570 hrs.
Average Ambient Temperature in Harrisburg, PA is 57.08° F[3]
Average Wind Speed in Harrisburg, PA is 18.52 mph (Dauphin County)[4]
Fuel Type – Gas
Fuel cost – 5 $/Mcf
Heat Content – 1026 (standard quality of gas fuel)
Outer Jacket Material = .016 aluminum
Jacket Emittance - .8

Item ID = 1
Item Description = Harrisburg, PA example
System Application = Pipe - Horizontal
Dimensional Standard = ASTM C 585 Rigid
Calculation Type = Cost of Energy
Process Temperature = 380
Ambient Temperature = 57.08
Wind Speed = 18.52
Fuel Name = Natural Gas
Heat Content = 1026
Efficiency = 75
Hours Per Year = 6570
Nominal Pipe Size = 6
Bare Metal = Steel
Bare Surface Emittance = 0.8
Insulation Layer 1 = 850F Mineral Fiber PIPE, Type I, C547-15
Outer Jacket Material = All Service Jacket
Outer Surface Emittance = 0.9

Variable Insulation Thickness	CO2 (lb/ft/yr)	CO2 MT (MT/ft/yr)	NOx (lb/ft/yr)
Bare	3928.00	1.78	7.88
0.5	414.70	0.19	0.83
1.0	222.40	0.10	0.45
1.5	156.80	0.07	0.31
2.0	120.80	0.05	0.24
2.5	102.00	0.05	0.20
3.0	89.20	0.04	0.18
3.5	78.02	0.04	0.16
4.0	71.41	0.03	0.14
4.5	66.17	0.03	0.13
5.0	61.90	0.03	0.12

Insulation Thickness (in)	Insulation Cost ($/ft)	Fuel Cost ($/ft/yr)	Fuel Savings ($/ft/yr)	Payback Period (yrs)	Heat Loss (kBT
Bare		164.28			25282
1.0	17.31	9.30	154.98	0.1	1431
1.5	19.84	6.56	157.72	0.1	1009
2.0	23.84	5.05	159.23	0.1	777
2.5	27.51	4.26	160.01	0.2	656
3.0	30.90	3.73	160.55	0.2	574
4.0	39.22	2.99	161.29	0.2	460

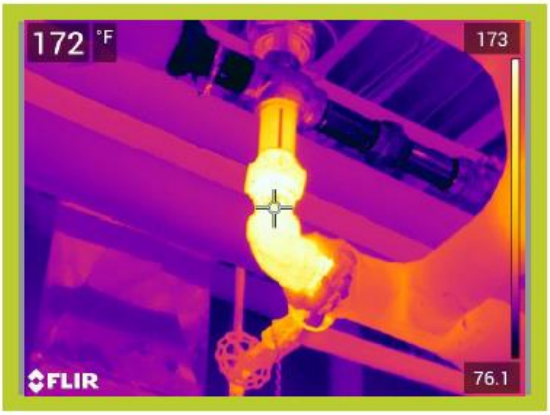
YEARLY Analysis of Wasted Resource's of a Non-Insulated Pipe Harrisburg						
	1'	10'	100'	1000'	10, 000'	non -insulated pipe
Cost	$159.23	$1,592.30	$15,923.00	$159,230.00	$1,592,300.00	Dollars
Energy	777.00	7,770.00	77,700.00	777,000.00	7,770,000.00	kbtu/ft/yr
Carbon	3,807.20	38,072.00	380,720.00	3,807,200.00	38,072,000.00	lbs/ft/yr

[3] (2) average yearly temperature Harrisburg, PA - Bing
[4] Maryland Average Wind Speed County Rank (usa.com)

4. Alternative Methodology

There is another very effective way to measure the energy loss as it relates to mechanical insulation. That is the use of a thermal infrared digital camera, a very specialized camera that offers visual evidence and measured energy loss. Although many claim the photography shows emitted heat, that is not exactly accurate. What it does is to measure the intensity of infrared radiation (radiant energy) being emitted by the surface it is aimed at that offers an amazing visual format.[5] Heat is a form of energy, but through infrared ray technology, which is displayed in a photographic form. Nevertheless, without knowing the science, it gives an instant realization of the value of mechanical insulation.

Here is an example of a standard photograph compared to a thermal image photograph (TIP). The TIP offers the visual impact of showing the heat, "Energy", loss as compared to the other insulated piping. Notice that the TIP is displaying the highest and graduated temperatures. In this case there is approximately 3' of exposed piping, from a prior piping repair that was not re-insulated, operating at 172°F.



A Mechanical Insulation Energy Audit was performed, and it was determined that these 3 feet of missing insulation is costing the owner $799.74 a year. The pipe repair was conducted 5 years prior. Without the insulation being replaced, it has costed a total $3998.70 of energy loss. If the insulation was properly repaired costing $500, it would have saved the owner $3,498.70 in that same 5-year time period.

Thermal imaging can be utilized in several different formats. It can be used within a comprehensive Mechanical Insulation Energy Audit that offers all the data calculations in conjunction with this very special visualization. Or it can also be used as a standalone Mechanical Insulation Energy Audit. It is all depending on what the owner is attempting to achieve and the depth of the audit desired. The use of a Thermal Imaging Camera does require proper training and should be performed with one that has a certification of use and analysis.

[5] Article by Martin Holladay January 6, 2019 – An Introduction to Thermal Imaging – The Green Builder Advisor – www.greenbuilderadvisor.com

5. Return on Investment – ROI

Return on investment (ROI) is a metric used to understand the profitability of an investment. ROI compares how much is paid for an investment to how much you earned to evaluate its efficiency.[6]

How long does the investment of installing Mechanical Insulation will pay for itself?

(a) – Cost of Installation
(b) - Cost of Energy not utilized per year
(c) - Time Period of years
(d) – Total Cost of Wasted Energy in a time period (d)
(e) – Amount saved, profit above investment in time period (c)
(f) – Ratio install cost/loss of energy based on year

(b) x (c) = (d) Total Cost of Wasted Energy in a time period (d)

(d) - (a) = (e) - Amount saved, profit above investment in time period (c)

(a) / (b) = (f) – Ratio install cost/loss of energy based on year

(f) x 12 = Amount of months needed to Return of Investment

Using the example in **Section # 4 Alternative Methodology**

A Mechanical Insulation Energy Audit was performed, and it was determined that these 3 feet of missing insulation is costing the owner $799.74 a year. The pipe repair was five years prior costing a total $3998.7 of energy loss. If the insulation was properly repaired costing $500, it would have saved the owner $3,498.70 in that same 5-year time period.

(799.74) x (5) = (3998.7) Total Cost of Wasted Energy in a time period (d)

(3998.7) - (500) = (3498.70) - Amount saved, profit above investment in time period (c)

(500) / (799.74) = (.625) – Ratio install cost/loss of energy based on year

(.625) x 12 = **7.5 months is needed achieve a Return of Investment**

This is only an example of the calculations that are utilized to determine the length of time needed to estimate when the investment of utilizing the installation costs of mechanical insulation. The biggest variable is the cost of installation. There are many variables that have to be considered when estimating a cost of a project. It is always recommended that consultation is perform with a qualified registered mechanical insulation contractor to receive an accurate estimate. However, most ROIs usually are achieved within 6 months to 2-year period range. [7]

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[6] Article by Emily Guy Birken, Benjamin Curry Understanding Return on Investment. Forbes Advisor WWW.Forbes.com

[7] Article on National Insulation Association – About Insulation web page www.insulation.org

6. Case Studies – Mechanical Insulation Energy Audits Performed in various locations.

Mechanical Insulation Energy Audits - Pennsylvania Energy Audits					
Type of Project (see Below)	Linear Footage	Money Saved	CO2 reduction	Nox reduction	Kbtus saved
Government	3055	$185,821.00	903647	1813	7.74E+06
University	8372	$123,544.00	1955090	3923	1.43E+06
University	2367	$ 31,506.00	495184	999	4.10E+06
Government	1023	$ 10,706.00	151325	304	1.04E+06
School District	758	$ 5,961.00	81117	163	5.58E+05
Hospital	225	$ 5,843.00	87325	175	6.00E+05
University	55	$ 5,681.00	32838	66	2.25E+05
School District	894	$ 4,967.00	87713	176	6.47E+05
School District	435	$ 4,091.00	71407	143	5.21E+05
School District	336	$ 1,263.00	30209	61	2.07E+05
School District	98	$ 466.00	8234	17	5.56E+04
totals	17,618	379,849	3,904,089	7,840	1.71E+07

The specific name of projects are protected by a privacy non-disclosure clause. I-Star, a subsidiary of IREX Contracting Group, performed the Mechanical Insulation Energy Audits, and have released the data as real-life examples. These were actual projects that were performed. If further verification is warranted, Insulators LMCT would pursue procedures to have permission to disclose the particulars about the project.

Environmental note:

The average passenger vehicle emits about 411 grams of CO_2 per mile and averaged about 21.6 miles per gallon.[8]

411 grams x .00220462 lbs. = .906 lbs. per mile of CO_2

3,904,089 lbs. /.906 per mile = **4,309,149 miles**

The 11 PA projects above with mechanical insulation installed prevented 3,904,089 lbs. of CO_2 into the environment which is equivalent to the exhaust of US passenger vehicles of **4.3 million miles.**

[8] http://nepis.epa.gov.

7. Who Benefits from Mechanical Insulation?

Who benefits from a properly working mechanical insulation system? The short answer is everybody. It conserves energy, saves money, and reduces harmful green-house gases that results in lowering the carbon footprint.

Any building, facilities, and structures that are design to have human occupancy will benefit with mechanical insulation. In addition to lowering the carbon footprint science, it also produces a safe and healthy living and work environments.

Apartment Buildings
Chemical Plants
Colleges / Universities
Factories
Government Building
Administration Buildings
Hospitals
Nuclear Power Plants
Office Buildings
Paper/Wood/Steel Mills
Pharmaceuticals
Power Plants
Refineries
Schools
Steel Mills
Manufacturing processes

As stated in the introduction, few people feel mechanical insulation is important enough to value their time to address its function. A dripping pipe, lights not working, leaking roof and other common building ailments are recognized easily to initiate the necessary corrective action, except mechanical insulation. It requires a more proactive methodology than a reactionary approach. Many times, the only realization the owner may know if there is a mechanical insulation problem is after a mechanical insulation inspection or a MIEA are performed. There are many reasons to have properly and professionally installed Mechanical Insulation. Some even reach beyond the monetary benefits; it benefits a safer and healthier society.

Mechanical Insulation benefits are, but not limited to.

- Conserve Energy –Electric, Gas, Geothermal, Hydro, Nuclear and Oil
- Reduce Operating Expenses of Mechanical Systems
- Extend the life cycle of mechanical equipment.
- Works toward and contributes to a “New Zero” society
- Reduces Carbon Footprint
- Personnel Protection (OSHA requirement)
- Condensation Control
- Improve process control and efficiency
- Improve work environment – Indoor Air Quality
- Mold and virus reduction
- To meet ANSI/ASHRAE standard 90.1
- To meet US Building and fire code