### Small Pipe Insulation

**Description**

This measure provides rebates for adding insulation to bare pipes with inner diameters of ½” and ¾”. Insulation must be at least one inch thick. Since new construction projects are required by code to have pipe insulation, this measure is only for retrofits of existing facilities. This covers bare straight pipe as well as all fittings.

Default savings are provided on a per linear foot basis. It is assumed that the majority of pipes less than one inch in commercial facilities are used for domestic hot water. However, this measure can cover hydronic heating systems as well as low and high pressure steam systems.

This measure was developed to be applicable to the following program types: RF.

If applied to other program types, the measure savings should be verified.

**Definition of Efficient Equipment**

The efficient case is a ½“or ¾“ diameter pipe with at least one inch of insulation. Insulation must be protected from damage which includes moisture, sunlight, equipment maintenance and wind. Outdoor pipes should have a weather protective jacket. Insulation must be continuous over straight pipe, elbows and tees.

**Definition of Baseline Equipment**

The base case for savings estimates is a bare hot water or steam pipe with a fluid temperature of 105 degrees Fahrenheit or greater. Current new construction code requires insulation amounts similar to this measure though this base case is commonly found in older existing buildings.

**Deemed Lifetime of Efficient Equipment**

The measure life is assumed to be 15 years.[[1]](#footnote-1)

**Deemed Measure Cost**

The incremental measure cost for insulation is the full cost of adding insulation to the pipe. Actual installation costs should be used for the measure cost. For planning purposes, the following costs can be used to estimate the full cost of materials and labor.[[2]](#footnote-2)

|  |  |  |
| --- | --- | --- |
| **Insulation Thickness** | **¾” pipe** | **½” pipe** |
| 1” | $4.45 | $4.15 |

**Loadshape**

N/A

**Coincidence Factor**

N/A

**Algorithm**

**Calculation of Energy Savings**

**Electric Energy Savings**

N/A

**Summer Coincident Peak Demand Savings**

N/A

**Natural Gas Savings**

Δtherms per foot[[3]](#footnote-3) = [((Qbase – Qeff) \* EFLH) / (100,000 \* ηBoiler)] \* TRF

= [Modeled or provided by tables below] \* TRF

Δtherms = (Lsp + Loc,i) \* Δtherms per foot

Where:

EFLH = Equivalent Full Load Hours for Heating

= Actual or defaults by building type provided in Section 4.4, HVAC end use

For year round recirculation or domestic hot water:

= 8,766

For heating season recirculation, hours with the outside air temperature below 55°F:

| **Zone** | **Hours** |
| --- | --- |
| Zone 1 (Rockford) | 5,039 |
| Zone 2 (Chicago) | 4,963 |
| Zone 3 (Springfield) | 4,495 |
| Zone 4 (Belleville/ | 4,021 |
| Zone 5 (Marion) | 4,150 |

Qbase = Heat Loss from Bare Pipe (Btu/hr/ft)

= Calculated where possible using 3E Plusv4.0 software. For defaults see table below

Qeff = Heat Loss from Insulated Pipe (Btu/hr/ft)

= Calculated where possible using 3E Plusv4.0 software. For defaults see table below

100,000 = conversion factor (1 therm = 100,000 Btu)

ηBoiler = Efficiency of the boiler being used to generate the hot water or steam in the pipe

= 81.9% for water boilers [[4]](#footnote-4)

= 80.7% for steam boilers, except multifamily low-pressure [[5]](#footnote-5)

= 64.8% for multifamily low-pressure steam boilers [[6]](#footnote-6)

TRF = Thermal Regain Factor for space type, applied only to space heating energy and is applied to values resulting from Δtherms/ft tables below [[7]](#footnote-7)

= See table below for base TRF values by pipe location

May vary seasonally such as: TRF[summer] \* summer hours + TRF[winter] \* winter hours where TRF values reflecting summer and winter conditions are apportioned by the hours for those conditions. TRF may also be adjusted by building specific balance temperature and operating hours above and below that balance temperature.[[8]](#footnote-8)

|  |  |  |
| --- | --- | --- |
| **Pipe Location** | **Assumed Regain** | **TRF, Thermal Regain Factor** |
| Outdoor | 0% | 1.0 |
| Indoor, heated space | 85% | 0.15 |
| Indoor, semi- heated, (unconditioned space, with heat transfer to conditioned space. E.g.: boiler room, ceiling plenum, basement, crawlspace, wall) | 30% | 0.70 |
| Indoor, unheated, (no heat transfer to conditioned space) | 0% | 1.0 |
| Location not specified | 85% | 0.15 |
| Custom | Custom | 1 – assumed regain |

Lsp = Length of straight pipe to be insulated (linear foot)

Loc,i = Total equivalent length of (elbows and tees) of pipe to be insulated. Use table below to determine equivalent lengths.

|  |  |  |
| --- | --- | --- |
| **Nominal Pipe Diameter** | **Equivalent Length (ft)** | |
| **90 Degree Elbow** | **Straight Tee** |
|
| 1/2" | 0.04 | 0.03 |
| 3/4" | 0.06 | 0.05 |

The table below shows the deemed therm savings by building type and region on a per linear foot basis for both ½” and ¾” copper pipe.

The following table provides deemed values for 1/2" copper pipe, temperatures are assumed by category below, and insulation is assumed to be one inch fiberglass.

| **Piping Use** | **Building Type** | **Annual Therms Saved / Linear Foot** | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Zone 1 (Rockford)** | **Zone 2 (Chicago)** | **Zone 3 (Springfield)** | **Zone 4 (Belleville)** | **Zone 5 (Marion)** |
| Space Heating Non-recirculating | Assembly | 0.117 | 0.120 | 0.107 | 0.071 | 0.109 |
| Assisted Living | 0.110 | 0.107 | 0.094 | 0.069 | 0.083 |
| College | 0.100 | 0.093 | 0.083 | 0.046 | 0.055 |
| Convenience Store | 0.097 | 0.089 | 0.079 | 0.057 | 0.064 |
| Elementary School | 0.116 | 0.113 | 0.100 | 0.069 | 0.084 |
| Garage | 0.064 | 0.063 | 0.056 | 0.044 | 0.049 |
| Grocery | 0.105 | 0.105 | 0.092 | 0.057 | 0.068 |
| Healthcare Clinic | 0.103 | 0.106 | 0.092 | 0.063 | 0.066 |
| High School | 0.120 | 0.121 | 0.109 | 0.077 | 0.091 |
| Hospital - CAV no econ | 0.115 | 0.119 | 0.101 | 0.087 | 0.099 |
| Hospital - CAV econ | 0.117 | 0.121 | 0.103 | 0.089 | 0.101 |
| Hospital - VAV econ | 0.048 | 0.045 | 0.034 | 0.020 | 0.022 |
| Hospital - FCU | 0.087 | 0.099 | 0.080 | 0.094 | 0.127 |
| Hotel/Motel | 0.115 | 0.112 | 0.101 | 0.069 | 0.084 |
| Hotel/Motel - Common | 0.104 | 0.106 | 0.101 | 0.082 | 0.086 |
| Hotel/Motel - Guest | 0.115 | 0.111 | 0.099 | 0.066 | 0.082 |
| Manufacturing Facility | 0.068 | 0.066 | 0.061 | 0.037 | 0.041 |
| MF - High Rise | 0.100 | 0.098 | 0.090 | 0.076 | 0.076 |
| MF - High Rise - Common | 0.118 | 0.115 | 0.103 | 0.071 | 0.092 |
| MF - High Rise - Residential | 0.096 | 0.096 | 0.087 | 0.075 | 0.073 |
| MF - Mid Rise | 0.109 | 0.110 | 0.095 | 0.070 | 0.079 |
| Movie Theater | 0.119 | 0.117 | 0.109 | 0.083 | 0.099 |
| Office - High Rise - CAV no econ | 0.132 | 0.134 | 0.122 | 0.082 | 0.089 |
| Office - High Rise - CAV econ | 0.136 | 0.139 | 0.128 | 0.088 | 0.097 |
| Office - High Rise - VAV econ | 0.100 | 0.102 | 0.084 | 0.050 | 0.055 |
| Office - High Rise - FCU | 0.073 | 0.072 | 0.062 | 0.033 | 0.035 |
| Office - Low Rise | 0.093 | 0.093 | 0.074 | 0.045 | 0.052 |
| Office - Mid Rise | 0.103 | 0.104 | 0.088 | 0.056 | 0.062 |
| Religious Building | 0.105 | 0.098 | 0.094 | 0.069 | 0.079 |
| Restaurant | 0.088 | 0.088 | 0.079 | 0.060 | 0.071 |
| Retail - Department Store | 0.091 | 0.083 | 0.078 | 0.051 | 0.058 |
| Retail - Strip Mall | 0.087 | 0.081 | 0.071 | 0.049 | 0.053 |
| Warehouse | 0.095 | 0.089 | 0.091 | 0.057 | 0.070 |
| Unknown | 0.101 | 0.100 | 0.089 | 0.064 | 0.074 |
| Space Heating - recirculation heating season only | All buildings (Hours below 55°F) | 0.329 | 0.324 | 0.293 | 0.262 | 0.271 |
| Space Heating - recirculation year round | All buildings (All hours) | 0.572 | 0.572 | 0.572 | 0.572 | 0.572 |
| DHW | Recirculation loop | 0.572 | 0.572 | 0.572 | 0.572 | 0.572 |
| Process | Custom | Custom | | | | |

The following table provides deemed savings values for 3/4" copper pipe with temperatures assumed by category below, insulation is assumed to be one inch fiberglass.

| **Piping Use** | **Building Type** | **Annual Therms Saved / Linear Foot** | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Zone 1 (Rockford)** | **Zone 2 (Chicago)** | **Zone 3 (Springfield)** | **Zone 4 (Belleville)** | **Zone 5 (Marion)** |
| Space Heating Non-recirculating | Assembly | 0.142 | 0.145 | 0.129 | 0.086 | 0.132 |
| Assisted Living | 0.133 | 0.130 | 0.115 | 0.084 | 0.101 |
| College | 0.121 | 0.113 | 0.101 | 0.056 | 0.067 |
| Convenience Store | 0.117 | 0.108 | 0.096 | 0.069 | 0.077 |
| Elementary School | 0.141 | 0.137 | 0.121 | 0.084 | 0.102 |
| Garage | 0.078 | 0.077 | 0.067 | 0.054 | 0.060 |
| Grocery | 0.127 | 0.127 | 0.111 | 0.069 | 0.083 |
| Healthcare Clinic | 0.125 | 0.128 | 0.112 | 0.076 | 0.081 |
| High School | 0.146 | 0.147 | 0.132 | 0.094 | 0.110 |
| Hospital - CAV no econ | 0.140 | 0.144 | 0.123 | 0.105 | 0.120 |
| Hospital - CAV econ | 0.142 | 0.147 | 0.125 | 0.108 | 0.123 |
| Hospital - VAV econ | 0.058 | 0.055 | 0.041 | 0.025 | 0.027 |
| Hospital - FCU | 0.105 | 0.120 | 0.098 | 0.115 | 0.154 |
| Hotel/Motel | 0.140 | 0.136 | 0.122 | 0.084 | 0.102 |
| Hotel/Motel - Common | 0.127 | 0.129 | 0.123 | 0.100 | 0.105 |
| Hotel/Motel - Guest | 0.139 | 0.135 | 0.120 | 0.081 | 0.099 |
| Manufacturing Facility | 0.083 | 0.080 | 0.074 | 0.045 | 0.050 |
| MF - High Rise | 0.121 | 0.119 | 0.109 | 0.093 | 0.093 |
| MF - High Rise - Common | 0.144 | 0.140 | 0.125 | 0.086 | 0.111 |
| MF - High Rise - Residential | 0.117 | 0.116 | 0.105 | 0.091 | 0.089 |
| MF - Mid Rise | 0.132 | 0.134 | 0.115 | 0.085 | 0.096 |
| Movie Theater | 0.144 | 0.142 | 0.133 | 0.101 | 0.120 |
| Office - High Rise - CAV no econ | 0.160 | 0.162 | 0.148 | 0.099 | 0.108 |
| Office - High Rise - CAV econ | 0.165 | 0.169 | 0.155 | 0.107 | 0.118 |
| Office - High Rise - VAV econ | 0.121 | 0.123 | 0.102 | 0.060 | 0.067 |
| Office - High Rise - FCU | 0.089 | 0.087 | 0.075 | 0.040 | 0.042 |
| Office - Low Rise | 0.113 | 0.113 | 0.090 | 0.055 | 0.063 |
| Office - Mid Rise | 0.126 | 0.126 | 0.106 | 0.068 | 0.075 |
| Religious Building | 0.127 | 0.119 | 0.114 | 0.084 | 0.095 |
| Restaurant | 0.107 | 0.107 | 0.096 | 0.073 | 0.086 |
| Retail - Department Store | 0.110 | 0.101 | 0.095 | 0.062 | 0.071 |
| Retail - Strip Mall | 0.106 | 0.098 | 0.086 | 0.059 | 0.064 |
| Warehouse | 0.115 | 0.108 | 0.111 | 0.069 | 0.085 |
| Unknown | 0.123 | 0.122 | 0.108 | 0.078 | 0.090 |
| Space Heating - recirculation heating season only | All buildings (Hours below 55°F) | 0.399 | 0.393 | 0.356 | 0.319 | 0.329 |
| Space Heating - recirculation year round | All buildings (All hours) | 0.694 | 0.694 | 0.694 | 0.694 | 0.694 |
| DHW | Recirculation loop | 0.694 | 0.694 | 0.694 | 0.694 | 0.694 |
| Process | Custom | Custom | | | | |

**Water Impact Descriptions and Calculation**

N/A

**Deemed O&M Cost Adjustment Calculation**

N/A

**Measure Code: CI-HVC-SPIN-V01-150601**

1. Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure\_life\_GDS%5B1%5D.pdf [↑](#footnote-ref-1)
2. A market survey was performed to determine these costs. [↑](#footnote-ref-2)
3. This value comes from the reference table “Savings Summary by Building Type and System Type.” The formula and the input tables in this section document assumptions used in calculation spreadsheet “Pipe Insulation Savings 2013-11-12.xlsx” [↑](#footnote-ref-3)
4. Average efficiencies of units from the California Energy Commission (CEC). [↑](#footnote-ref-4)
5. Ibid. [↑](#footnote-ref-5)
6. Katrakis, J. and T.S. Zawacki. “Field-Measured Seasonal Efficiency of Intermediate-sized Low-Pressure Steam Boilers”. ASHRAE V99, pt. 2, 1993. [↑](#footnote-ref-6)
7. Thermal regain for *residential* pipe insulation measures is discussed in Home Energy Services Impact Evaluation, prepared for the Massachusetts Residential Retrofit and Low Income Program Area Evaluation, Cadmus Group, Inc., August 2012 and Andrews, John, Better Duct Systems for Home Heating and Cooling, U.S. Department of Energy, 2001. Recognizing the differences between residential and commercial heating systems, the factors have been adjusted based on professional judgment. This factor would benefit from additional study and evaluation. [↑](#footnote-ref-7)
8. Thermal Regain Factor\_4-30-14.docx [↑](#footnote-ref-8)