**Workpaper WPSCGNRM1050101A**

**Revision 2**

**Southern California Gas Company**

**Customer Programs Department**

**Tank Insulation for**

**Commercial and Industrial Applications**

Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision No. | Date | **Description** | **Author (Company)** |
| Superseded |  | Pipe and Tank insulation WP (WPSCGNRM1050101A) | SCG |
| 1 | 08/29/2012 | Tank Insulation Workpaper PGECOPRO103 (rev.4) | PG&E |
| 2 | 05/14/2014 | Updated CEC 2014 code, measure IMC, and included all 16 statewide weather zones. Savings were calculated for two operating plant schedules (continuous and half day operation) | Raad Bashar (SCG) |
|  |  |  |  |
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|  |  |  |  |

Measure Summary Table

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Measure ID | Measure Name | Program Application Type (RE, NC, ROB, ER, etc) | EUR/RUL (yr) | CZ | Building Type | Building Vintage | Unit  Definition | NTG IMC | NTG Savings | Program Delivery Method (CustIncent, PreReb, Dirinstall, etc) | Gross Realization Rate (GRR) | % Eligible for TOU AC Adjustment |
| 1 | 1” thick tank insulation – liquid or solution temperature 120–170ºF-8760 | REA | 11 | Any | Com | Ex | Sq.ft. | 0.6 | 0.6 | PreReb | 1 | N/A |
| 2 | 1” thick tank insulation – liquid or solution temperature 120–170ºF-8760 | REA | 11 | 1 | Com | Ex | Sq.ft. | 0.6 | 0.6 | PreReb | 1 | N/A |
| 18 | 1” thick tank insulation – liquid or solution temperature 170-200ºF-8760 | REA | 11 | Any | Com | Ex | Sq.ft. | 0.6 | 0.6 | PreReb | 1 | N/A |
| 19 | 1” thick tank insulation – liquid or solution temperature 170-200ºF-8760 | REA | 11 | 1 | Com | Ex | Sq.ft. | 0.6 | 0.6 | PreReb | 1 | N/A |
| 35 | 2” thick tank insulation – liquid or solution temperature 120–170ºF-8760 | REA | 11 | Any | Com | Ex | Sq.ft. | 0.6 | 0.6 | PreReb | 1 | N/A |
| 36 | 2” thick tank insulation – liquid or solution temperature 120–170ºF-8760 | REA | 11 | 1 | Com | Ex | Sq.ft. | 0.6 | 0.6 | PreReb | 1 | N/A |
| 52 | 2” thick tank insulation – liquid or solution temperature 170-200ºF-8760 | REA | 11 | Any | Com | Ex | Sq.ft. | 0.6 | 0.6 | PreReb | 1 | N/A |
| 53 | 2” thick tank insulation – liquid or solution temperature 170-200ºF-8760 | REA | 11 | 1 | Com | Ex | Sq.ft. | 0.6 | 0.6 | PreReb | 1 | N/A |
| 69 | 1” thick tank insulation – liquid or solution temperature 120–170ºF-3744 | REA | 11 | Any | Com | Ex | Sq.ft. | 0.6 | 0.6 | PreReb | 1 | N/A |
| 70 | 1” thick tank insulation – liquid or solution temperature 120–170ºF-3744 | REA | 11 | 1 | Com | Ex | Sq.ft. | 0.6 | 0.6 | PreReb | 1 | N/A |
| 86 | 1” thick tank insulation – liquid or solution temperature 170-200ºF-3744 | REA | 11 | Any | Com | Ex | Sq.ft. | 0.6 | 0.6 | PreReb | 1 | N/A |
| 87 | 1” thick tank insulation – liquid or solution temperature 170-200ºF-3744 | REA | 11 | 1 | Com | Ex | Sq.ft. | 0.6 | 0.6 | PreReb | 1 | N/A |

* Savings are based on continuous operation (8760 hours/yr) schedule.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Measure ID | Measure Name | 1st Baseline | | | | 2nd Baseline | | | |
| Gas Savings  (therms) | Base Total Cost ($/unit) | Measure Total Cost ($/unit) | Incremental Measure Cost ($/unit) | Gas Savings  (therms) | Base Total Cost ($/unit) | Measure Total Cost ($/unit) | Incremental Measure Cost ($/unit) |
|
| 1 | 1” thick tank insulation – liquid or solution temperature 120–170ºF-8760 | 11.70 | $0 | $9.49 | $9.49 | N/A | N/A | N/A | N/A |
| 2 | 1” thick tank insulation – liquid or solution temperature 120–170ºF-8760 | 16.12 | $0 | $9.49 | $9.49 | N/A | N/A | N/A | N/A |
| 18 | 1” thick tank insulation – liquid or solution temperature 170-200ºF-8760 | 20.74 | $0 | $9.49 | $9.49 | N/A | N/A | N/A | N/A |
| 19 | 1” thick tank insulation – liquid or solution temperature 170-200ºF-8760 | 25.53 | $0 | $9.49 | $9.49 | N/A | N/A | N/A | N/A |
| 35 | 2” thick tank insulation – liquid or solution temperature 120–170ºF-8760 | 12.38 | $0 | $12.04 | $12.04 | N/A | N/A | N/A | N/A |
| 36 | 2” thick tank insulation – liquid or solution temperature 120–170ºF-8760 | 17.07 | $0 | $12.04 | $12.04 | N/A | N/A | N/A | N/A |
| 52 | 2” thick tank insulation – liquid or solution temperature 170-200ºF-8760 | 21.90 | $0 | $12.04 | $12.04 | N/A | N/A | N/A | N/A |
| 53 | 2” thick tank insulation – liquid or solution temperature 170-200ºF-8760 | 26.99 | $0 | $12.04 | $12.04 | N/A | N/A | N/A | N/A |
| 69 | 1” thick tank insulation – liquid or solution temperature 120–170ºF-3744 | 5.00 | $0 | $9.49 | $9.49 | N/A | N/A | N/A | N/A |
| 70 | 1” thick tank insulation – liquid or solution temperature 120–170ºF-3744 | 6.89 | $0 | $9.49 | $9.49 | N/A | N/A | N/A | N/A |
| 86 | 1” thick tank insulation – liquid or solution temperature 170-200ºF-3744 | 8.86 | $0 | $9.49 | $9.49 | N/A | N/A | N/A | N/A |
| 87 | 1” thick tank insulation – liquid or solution temperature 170-200ºF-3744 | 5.89 | $0 | $9.49 | $9.49 | N/A | N/A | N/A | N/A |

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1. General Measure & Baseline Data

Measure & Delivery Description

Technical Description

* + - 1. Owing to first cost sensitivity and/or a low level of awareness, many commercial and industrial customers – particularly smaller, hard to reach businesses – install tanks and piping systems with no insulation. These measures address cost-effective energy efficiency opportunities in the tank insulation area.
      2. Installing insulation on a bare surface greatly reduces heat losses to ambient air, achieving significant energy savings at a relatively low cost.

Application Process:

The insulation thickness and tank solution temperature will determine the rebate amount.

Must include manufacturer’s name, insulation material type and the material k-value rating.

Terms and Conditions

See Catalog Description above.

Market Applicability

This measure applies to most commercial and industrial facilities, including, but not limited to, offices, restaurants, retail, schools, colleges, hotels, motels, and recreational facilities.

Requirements:

One or two inch thick insulation of fiberglass or foam insulation must be added to existing bare liquid, solution storage or transfer tanks.

The tanks must be coupled to gas-fired commercial or industrial equipment that transfers heat to the contained liquid or solution.

Tanks with pre-existing insulation do not qualify for a rebate. This rebate cannot be used for the replacement of old or damaged insulation.

California Building Energy Efficiency Standards (Title 24), Section 123 establishes requirements for tank insulation in the design and installation of space-conditioning and service water heating systems and equipment. Any tank requiring insulation per these standards does not qualify for a rebate.

Tanks insulated to prevent burns do not qualify for rebate. The Occupational Safety and Health Standards Board, Section 3308 requires employers to insulate or guard hot pipes and hot surfaces of 140 degrees F or higher, that are located within 7 feet of the floor or within 15 inches from stairways, ramps or fixed ladders. Any tank requiring insulation per these standards does not qualify for a rebate.

DEER Differences Analysis

The DEER database does not contain any measure for tank surface insulation.

Code Analysis

California Building Energy Efficiency Standards (Title 24), Section 123 establishes requirements for tank insulation in the design and installation of space-conditioning and service water heating systems and equipment. Any tank requiring insulation per these standards does not qualify for a rebate.

The Occupational Safety and Health Standards Board, Section 3308 requires employers to insulate or guard hot pipes and hot surfaces of 140 degrees F or higher, that are located within 7 feet of the floor or within 15 inches from stairways, ramps or fixed ladders. Any tank requiring insulation per these standards does not qualify for a rebate.

Measure Effective Useful Life

Currently, there is no DEER measure for this type of insulation installation. There is however pipe insulation measure, Measure ID: WtrHt-PipeIns-Gas (Commercial) from DEER 2013[[1]](#endnote-1) identifies as having an 11-years life for gas water heater and a life of 13 years for electric water heater. A value of 11 years is used in this work paper as the EUL for commercial and industrial tank insulation.

Net-to-Gross Ratios for Different Program Strategies

Table 1 below summarizes all applicable Net-to-Gross ratios for programs that may be used by this measure. The NTGR for this measure is a default value taken from DEER 2013[[2]](#endnote-2) equaling 0.60. This NTGR represents the default for existing industrial measures with no evaluated NTGR that have had the same delivery mechanism for more than two years.

Table 1 - Net-to-Gross Ratios

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  | **DEER Spreadsheet** | |
| Program Approach | NTG | NTGR\_ID | File name | Cell Number |
| ALL | 0.60 | Ind-Default>2yrs | DEER2013Support Table\_NTGR.xlsx | E52 |

* 1. Gross Realization Rate

Gross realization rate of 1.0 was applied for this measure.

Time-of-Use Adjustment Factor

* + 1. N/A

1. Energy Savings & Demand Reduction Calculations

Load Shapes

* + 1. Load shapes are not applicable to gas measures.

2.1 Electric Energy Savings Estimation Methodologies

There is no electric energy savings associated with this gas measure.

2.2. Demand Reduction Estimation Methodologies

There is no demand reduction associated with this gas measures.

Energy Savings

The savings from this method result from reduced heat losses on the tank surface, resulting in reduced heating load on the connected gas-fired equipment. The savings were calculated as the difference in heat losses between the uninsulated tank surface (base case) and the insulated surface (measure). Average boiler efficiency (calculated from the CEC boiler listing) [[3]](#endnote-3) was then factored in to translate the reduced heat losses from the tank into reduced gas consumption of the boiler.

Methodology

The annual energy saved by tank insulation can be calculated as follows:

x As

Where:

Q = annual energy savings (in therms)

t = annual operating time, in hours

Qb = Heat Loss from Bare Tank (Btu/hr/ft2)

Qi = Heat Loss from Insulated Tank (Btu/hr/ft2)

Eb = Efficiency (%) of the boiler being used to generate the hot water in the tank

As = Tank surface area, not included ends of tank (ft2)

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

Heat loss calculations

The heat loss calculations were performed using industry-accepted software from the North American Insulation Manufacturers Association (NAIMA). The NAIMA 3E Plus v4.1 software [[4]](#endnote-4) uses the calculation methodology from the most recent version of the ASTM C 680 Standard.[[5]](#endnote-5) The main inputs used in the software were:

Base case: bare surface (to stay consistent with catalog Terms and Conditions)

Base tank material: steel – emissivity: 0.8  
Steel is the most common material for hot water tanks

Insulation material: Fiber glass-type insulation (cellular glass BLOCK, Gr1, C552-07). The temperature-dependent thermal conductivity of the fiber glass used by 3E Plus software is shown in Table 2 – Table 2. Foam insulation (the other acceptable type of material in this measure) has similar R-values to fiber glass and provides similar savings to fiberglass, since the savings are driven primarily by the heat losses from the base case (uninsulated tank).

Table 2 - Insulation Conductivity



Jacket material: Aluminum, new, emittance: 0.04

Operating hours: Two operating schedules were considered for this measure.

A continuous operation with 8,760 hours / yr

12 hours/day, and 6 days/week schedule, totaling 3,744 hrs/yr (assuming midsize industrial operation plant)

Process temperature (temperature inside the tank): 145ºF for low temperature range and 185ºF for high temperature range.   
Temperatures were chosen as the midpoints of the temperature ranges for each measure. 145ºF = (120 ºF +170 ºF)/2, 185 ºF = (170 ºF +200 ºF)/2

Zone Weather Conditions: Conditions of the air surrounding the tank (primarily temperature and wind speed) have to be estimated, as follows:

Outdoor ambient conditions, the DEER 2013 Annual average dry-bulb temperatures in degree F and Wind Speed in mph are selected for the 16 weather zones. Each monthly average Wind Speed was adjusted for the proper height at the plant (30% of the speed in the weather file) since weather station wind measurements are at heights of 10 to 30 feet.

For Tanks located indoors, the indoor air conditions were assumed with an air temperature of 75ºF and wind speed of 0 mph.

Boiler efficiency

To convert reduced heat losses from the tank into energy savings of the boiler, boiler efficiency needs to be taken into account. To determine representative boiler efficiencies, data from the California Energy Commission (CEC was examined.3 The CEC lists several hundred steam and hot water boilers. The average efficiency of the boilers in this listing was calculated for hot water boilers, both for small and large boilers listings. We obtained an average efficiency value of 82.5% for hot water boilers and used this value to compute the energy input for hot water.

The figure below shows the distribution of thermal efficiencies based on the CEC listing data.

1. Distribution of Thermal Efficiencies for Hot Water Boilers (300-2,500 MBtu/hr) in the CEC Appliance Efficiency Database

Results

Tables 3 & 4 below, presents the inputs and the results for an indoor tank insulation of this measure with the following operating schedules:

Table-3: for 8,760 hrs/yr and 1 & 2 inches thickness of insulation

Table-4: for 3,744 hrs/yr and 1 inch of insulation.

Table 3 - Energy Savings Calculations

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure code** | **Low temperature tank** | | **High temperature tank** | |
| Tank contents temperature range | 120-170 | 120-170 | 170-200 | 170-200 |
| Tank contents assumed temperature (for calculations) | 145 | | 185 | |
| Assumed annual operating hours | 8,760 | | | |
| Average boiler efficiency | 82.5% | | | |
| **Base case** |  |  |  |  |
| Heat loss from 3EPlus software (Btu/hr.ft²) | 125.7 | | 221.5 | |
| Yearly energy consumption (therms/ft².yr) | 13.35 | | 23.52 | |
| **Proposed case - with insulation** |  |  |  |  |
| Insulation thickness (inches) | 1 | 2 | 1 | 2 |
| Heat loss from 3EPlus software (Btu/hr.ft²) | 15.47 | 9.11 | 26.21 | 15.25 |
| Yearly energy consumption (therms/ft².yr) | 1.64 | 0.97 | 2.78 | 1.62 |
| Heat loss reduction (Btu/hr.ft²) | 110.23 | 116.59 | 195.29 | 206.25 |
| **Annual energy savings (therms/yr.ft²)** | **11.70** | **12.38** | **20.74** | **21.90** |

Table 4 - Energy Savings Calculations

|  |  |  |
| --- | --- | --- |
| **Measure code** | **Low temperature tank** | **High temperature tank** |
| Tank contents temperature range | 120-170 | 170-200 |
| Tank contents assumed temperature (for calculations) | 145 | 185 |
| Assumed annual operating hours | 3,744 | |
| Average boiler efficiency | 82.5% | |
| **Base case** |  |  |
| Heat loss from 3EPlus software (Btu/hr.ft²) | 125.7 | 221.5 |
| Yearly energy consumption (therms/ft².yr) | 5.70 | 10.05 |
| **Proposed case - with insulation** |  |  |
| Insulation thickness (inches) | 1 | 1 |
| Heat loss from 3EPlus software (Btu/hr.ft²) | 15.47 | 26.21 |
| Yearly energy consumption (therms/ft².yr) | 0.70 | 1.19 |
| Heat loss reduction (Btu/hr.ft²) | 110.23 | 195.29 |
| **Annual energy savings (therms/yr.ft²)** | **5.00** | **8.86** |

1. Base Case & Measure Costs

Base Case Cost

There are no base case costs associated with these measures. The base case is existing tanks with no insulation.

Gross Measure Cost

Typical material costs for this measure were estimated using the McMaster-Carr website.[[6]](#endnote-6) The cost data below was updated to match the McMaster-Carr data as of June 2012. Different insulation materials meeting the measures requirements were priced for 1 inch and 2 inch thicknesses, and a simple average of this cost was used, as in table-5.

Typical installation labor costs were calculated using the RS Means[[7]](#endnote-7) and assuming a 25% overhead and profit (O&P). The 2014 version of RS Means Mechanical Cost Data provided the labor cost, as shown in table-6.

Table 5 - Measure materials costs6

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Material Cost** | **Material** | **Material Cost ($ / ft²)** | | **McMaster Item** |
| **1 inch thickness** | Rigid fiberglass w. aluminum jacket |  | 1.75 | 9350K1 |
| Rigid polystyrene foam |  | 1.71 | 9255K1 |
| Fiberglass | *0.72* |  | 9160K4 |
| *Aluminum insulation jacketing* | *1.91* |  |  |
| Fiberglass + aluminum jacket - total cost |  | 2.63 |  |
| **2 inch thickness** | Rigid fiberglass w. aluminum jacket |  | 2.68 | 9350K3 |
| Rigid polystyrene foam |  | 3.27 | 9255K3 |
| Fiberglass | *0.83* |  | 9346K38 |
| *Aluminum insulation jacketing* | *1.91* |  |  |
| Fiberglass + aluminum jacket - total cost |  | 2.74 |  |
|  | **Average cost ($ / ft² ) for 1 inch** |  | **2.18** |  |
|  | **Average cost ($ / ft² ) for 2 inch** |  | **2.85** |  |

Table 6 - Measure labor costs7

|  |  |  |  |
| --- | --- | --- | --- |
| **Labor Costs** | **Labor without O&P ( $ / ft² )** | **Labor include O&P ( $ / ft² )** | **RS Means Item #** |
| **I inch insulation** | $5.85 | $7.31 | 23 07 16.10 2420 |
| **2 inch insulation** | $7.35 | $9.19 | 24 07 16.10 2440 |
|  |  |  |  |
| % O&P assumed |  | 25% |  |

Table 7 - Measure total costs

|  |  |  |
| --- | --- | --- |
| **Cost Summary** | **1 inch insulation** | **2 inch insulation** |
| **Material costs ($ / ft²)** | $2.18 | $2.85 |
| **Labor Costs ($ / ft²)** | $7.31 | $9.19 |
| **Total Cost ($ / ft²)** | $9.49 | $12.04 |

Incremental Measure Cost

Incremental costs are equal to measure costs since the base costs are zero. Full measure costs are equal to measure costs.

Attachments







References

1. *Technology and Measure Cost Data/Effective and Remaining Useful Life (EUL/RUL) Values. (“DEER2014 Database for Energy-Efficiency Resources, READI\_v1.0.4, Updated for 2014 Codes (* [*http://www.deeresources.com/*](http://www.deeresources.com/)*).* [↑](#endnote-ref-1)
2. *DEER 2014 Net-To-Gross Ratios (“DEER2013 Database for Energy-Efficiency Resources, READI\_v1.0.4, Updated for 2014 Codes (found at* [*http://www.deeresources.com*](http://www.deeresources.com)*)* [↑](#endnote-ref-2)
3. *California Energy Commission Appliance Efficiency Database at*

   [*http://www.appliances.energy.ca.gov/AdvancedSearch.aspx*](http://www.appliances.energy.ca.gov/AdvancedSearch.aspx) [↑](#endnote-ref-3)
4. *3E Plus® v4.1 Insulation Thickness Computer Program -* [*http://www.pipeinsulation.org/*](http://www.pipeinsulation.org/) [↑](#endnote-ref-4)
5. *ASTM C 680 Standard Practices for Determination of Heat Gain or Loss and the Surface Temperature of Insulation Piping on Equipment Systems by the Use of a Computer System –* [*www.astm.org*](http://www.astm.org) [↑](#endnote-ref-5)
6. *McMaster-Carr catalog, items #9350K1, 9255K1, 9160K4, 9350K3, 9255K3, 9346K38*

   [*www.mcmaster.com*](http://www.mcmaster.com) *, retrieved March 2014* [↑](#endnote-ref-6)
7. *2014 RS Means Mechanical Cost Data, item # 23 07 16.10 2420/2440 on page 267* [↑](#endnote-ref-7)